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BRITISH WOODPECKERS.

BY G. EDWARD MASSEE.

(With a Coloured Plate.)

The group *Scansores*, or climbers, is represented in the British Isles by three families, which include seventeen species, out of which eight only can be considered indigenous; the remaining nine being merely visitors of rare occurrence. The genus *Picus* contains but three true British species, though six others have been added to the list of British birds, on the grounds of one or two of each having been captured or seen here.

The places most frequented by woodpeckers are forest districts, where, amongst the interstices of the bark, and the decayed portions of the trees, they find a constant supply of insects and their larvæ, which constitute the principal part of their food, and for the capture of which their whole frame is admirably adapted. The hæmal spines, which in most of the vertebrata are distinct, are coalesced in birds into a single bone, called the *sternum*, or breastbone, which is subject to various modifications in different families. Birds whose food is principally taken on the wing, or who have to fly long distances to procure it, have in general a broad breastbone, furnished with a prominent keel or ridge descending from the median line of its under surface, to which the *pectoral*, or wing-muscles, are attached. In the present genus, whose food is principally procured in forests, and whose flight is rarely extended beyond the distance from one tree to another, the crest, or central ridge of the breastbone, is remarkably small. Their powerful toes, two of which are directed forwards and two backwards, are furnished with large, deeply curved claws, by which they are enabled, with the assistance of their stiff and pointed tail feathers, to move along the trunks and branches of trees in all directions. The beak is long, straight, and tapering from base to apex. The tongue is retractile, and the tip is armed with barb-like bristles, by which their insect prey is impaled.

The Green Woodpecker (*Picus viridis*, Linn.) is best known and most widely distributed amongst British species, but, in common with the rest of the genus, it possesses the facility of quickly moving its position on the trunk of a tree so as to interpose an efficient screen between itself and any observer, its green plumage harmonizing with the surrounding objects, and its shy and retiring habits, lead to the belief that this bird is more rare than it really is. During the spring months the silence of the forest is often broken by the loud monotonous cry of this bird, which, once heard, will never be forgotten; it is most frequently uttered before impending rain, and thus serves as a barometer to the woodman, as does the pimpernel to the shepherd. Its flight is heavy and undulated, but on the rough surface of a tree its movements more resemble those of a snake than of a bird, its brilliant crimson crown flashing like flame when lighted by the sun's rays, as it glides in a spiral manner round the stem, tapping the bark to dislodge the numerous insects which shelter amongst its irregularities. It may also be frequently seen on the ground in the vicinity of ant-hills, feeding on the ants and their eggs, to which it is very partial. The nest is placed in a decayed tree, the cavity being excavated or enlarged to suit its wants; the eggs are pure white, from four to six in number, and are deposited on a layer of decayed wood without any other lining. This bird is often dislodged from its breeding place by the common starling, which, though inferior in size, invariably succeeds in taking possession of the contested cavity, in which it builds its nest.

The Great Spotted Woodpecker (*Picus major*, Linn.) is less frequent than the preceding species, which, however, it much resembles in its habits, with the exception that it is more frequently seen apart from woods, in places where old posts or stumps abound, under the decayed bark of which live innumerable insects, on which it feeds, both in the larval and *imago*, or perfect state.

Mr. Gould, in his *Birds of Europe*, speaking of this species, says, "Nor are they free from plundering the fruit-trees of the garden, and, in fact, commit great havoc among cherries, plums, and wall-fruit in general." Having succeeded in keeping a bird of this species in confinement for nearly two years, my observations lead me to form an opinion differing from that stated by the above-mentioned author. The young woodpecker was taken from the nest before the quill feathers were developed, and was kept in a small box, where it was fed with various kinds of insects and spiders. When it was two months old I placed it in a small canary cage. The bottom and the sides, to the height of two inches, were composed of beechwood, which was rather decayed, and

perforated in all directions by the larvæ of a small beetle (*Ptinus pectinicornis*). The remainder of the cage was composed of wire, through which it tried to escape, but finding it impracticable, commenced beating in quick time at various parts of the woodwork with its beak. About ten minutes after leaving the room in which the cage was, I was called by the servant, who said that the bird had escaped and flown up the chimney. It was with difficulty that I captured it, and on taking down the cage I found to my surprise that in so short a time it had bored a hole sufficiently large in the bottom of the cage to allow of its escape. Whether it had pecked away the wood in search of the beetles, or with the intention of escaping, I cannot say. After fixing a stouter piece of wood over the hole in the cage, I returned it, but it repeatedly succeeded in effecting its escape, when it would perch on the head of any one present, and invariably commence an attack on the face and eyes. I afterwards placed it in a cage, composed wholly of wire, and provided it with wood, which, if suitable, was perforated in all directions. It never became tame, but regularly attacked my hand when I offered it food. The cat, too, kept at a considerable distance from the cage, after having once received a severe peck on the nose from the point of its powerful beak, while looking for a space large enough for the introduction of her foot. Its food consisted of insects, and during the winter months, when these could not be procured, I found a good substitute in uncooked meat, but fruit, nuts, or seeds of any description were invariably rejected. It never attempted to sit on the perches that were provided for it, but scrambled round the sides of the cage by clinging to the wires after the manner of parrots, with the exception that it never made use of its bill to assist its movements.

It is generally believed that these birds convey to a distance from the place, the chippings which are made during the excavation of the nest, which would, if allowed to remain at the root of the tree, lead to the detection of the nest. A careful observation of the habits of them, both in confinement and in their native woods, has led me to the conclusion that this is not their usual practice. When a piece of wood was given to my caged bird, it at once proceeded to test its soundness, by dealing in quick succession a series of hard blows with the point of its beak, on various parts of the surface. If it proved to be perfectly sound, it was left untouched; but if at all decayed, the bird would drill first a small hole with the point of its beak, which it afterwards enlarged by pecking off minute pieces from the circumference until it was as large as desired. While engaged in this task it would stop at intervals, and climb round the sides of its cage apparently for the sake of viewing

its work from all points; at the same time uttering a peculiar low chuckle, as if satisfied with its performance. Of the different kinds of wood given to it, the favourite piece was either beech or fir, and if these two were placed in the cage together, it invariably commenced upon the beech. I never found amongst the *debris* a chip larger than a grain of wheat, but the greater portion was like fine sawdust. The holes bored were always round. Now it is well known that these birds always choose for their breeding-place trees which are decayed or hollow in the centre. Inside the bark, where the wood is partly decayed, the woodpecker scoops out a hollow sufficiently large to contain its eggs, generally selecting for this purpose a position about a foot below the entrance, and the *debris* made during the construction of the nest falls into the hollow of the tree. Last year the upper part of an old oak was blown down in Castle Howard park. In the remaining portion of the trunk was a woodpecker's nest, found by me before the accident occurred to the tree, but which I could not reach from the outside. On climbing up the shattered trunk, I found the centre hollow, and round the circumference were five woodpeckers' nests, one of which contained four eggs, and at the bottom of the tree was a large accumulation of particles of decayed wood, the result of the labours of these birds, while making their nests, or searching for insects.

The Great Spotted Woodpecker is inferior in size to the Green Woodpecker; the general colour of its plumage is black and white, the crown and the feathers near the undertail coverts are bright crimson.

Lesser Spotted Woodpecker (*Picus minor*, Linn.). This is the rarest, as well as the smallest of the British woodpeckers; its total length not exceeding five and a half inches. In the colour of its plumage this bird somewhat resembles the last-mentioned species, but may be distinguished from it by its smaller size, and by the greater amount of white on the wings. It frequents woods, orchards, and isolated trees in search of food, which, like that of its congeners, consists of insects. It is exceedingly shy, and when surprised, seldom seeks safety in flight, but trusts to its activity in keeping a branch between itself and the object of its alarm. Its note is loud for so small a bird, and is like the noise made by the turning of a crank, whence its local name of crank-bird. The eggs are white, like those of the two preceding species, and are found in the same situations.

The three following birds are natives of North America, and are separately described in *Wilson's American Ornithology*, Jameson's edition:—

Downy Woodpecker (*Picus pubescens*, Linn.).

Golden-winged Woodpecker (*Picus auratus*, Linn.).

Hairy Woodpecker (*Picus villosus*, Linn.). Surely Montagu was mistaken in supposing that this species was common in the North of England.

Great Black Woodpecker (*Picus martius*, Linn.). The nest of this bird, containing four eggs, was found by my friend Mr. Wise in the New Forest, Hants.

Three-toed Woodpecker (*Picus tridactylus*, Linn.). This and the preceding species are not uncommon in certain districts of the European continent.

Middle Spotted Woodpecker (*Picus medius*, Linn.). This is now proved beyond doubt to be the young of the Great Spotted Woodpecker (*Picus major*, Linn.).

DESCRIPTION OF THE PLATE.

Fig. 1. Green Woodpecker (*Picus viridis*); Fig. 2. Great Spotted Woodpecker (*Picus major*); Figs. 3 and 4. Male and female of the Lesser Spotted Woodpecker (*Picus minor*).

ON THE APPLICABILITY OF THE ELECTRIC LIGHT TO LIGHTHOUSES.

BY PROFESSOR M'GAULEY.

NOTHING can be more important to any maritime country, but especially to one having so extended a commerce as ours, than the subject of lighthouses. Their importance is evident from the fact that the sudden and unexpected extinction of one of the lights on our coasts might cause the loss of many lives, and the destruction of many hundreds of thousands of pounds of property; and accordingly we consider it good policy to spend very large sums annually in the construction and maintenance of lighthouses.

Warning the mariner of the dangers which he incurs on his approach to land is not a mere modern practice. Beacon fires are of high antiquity; they are alluded to by Homer and several ancient writers. The celebrated Pharos of Alexandria was erected about three hundred years before Christ; but whether its light was that of a fire, or was produced by some more elaborate contrivance, cannot now be ascertained. It is said to have been visible at the distance of forty miles, but this is more than improbable. The famous Colossus of Rhodes, one of the wonders of ancient times, an immense statue of bronze, was erected about the same period; but, after a very few years, it was thrown down by an earth-

quake, and it remained where it fell until the close of the seventh century of the Christian era, when its materials were sold to a merchant of Edessa for a sum equivalent to thirty-six thousand pounds of our money. The Tour de Cordouan, at the mouth of the Garonne, is one of the most ancient of the modern lighthouses; a fire of wood was first used in it, then one of coal, and afterwards lamps and reflectors. To it was first practically applied the dioptric apparatus, which has brought lighthouse illumination to such a state of perfection. Until a comparatively recent period, grates with burning coals continued to be employed to warn the mariner. One of these is still to be seen at Lucerne in Switzerland, in the very place where it was long exhibited for the purpose of guiding the boatmen on the lake at night; and to it is most probably due the name of the interesting old town, where it still attracts the attention of the traveller.

The ingenuity of modern times was not satisfied with the contrivances with which the rude nations of antiquity were content. The clumsy grate, with a wood or charcoal fire, was superseded by the more steady and brilliant light of lamps: and means were devised for directing the light thus obtained, in all its intensity, to those points at which it was required. Reflectors were first used for the purpose; and as, from their nature, they are easily acted on and deteriorated by the atmosphere, it was often sought to supersede them by lenses, but long in vain. The imperfect figure of the lenses which would be sufficiently large for the purpose, the impossibility of obtaining considerable masses of glass free from serious imperfections, the large quantity of light absorbed by such great thicknesses even of the most transparent material, all conspired to render the numerous experiments made on the subject unsuccessful; until the persevering ingenuity of scientific men eliminated every difficulty, and at length produced the magnificent dioptric apparatus now in use.

Buffon endeavoured to diminish the absorption of light which occurs with large lenses, by cutting away their superfluous portions, and causing them to consist of a number of concentric zones or rings; but the impossibility of properly polishing the complicated surface, caused at one side of the lens by the different zones, also the liability to irregularity of curve, and the certainty of flaws in the large masses of glass required, rendered the expedient, however ingenious, inapplicable in practice.

But all these obstacles to complete success were overcome by the sagacity of Sir David Brewster, who, through a long and valuable life, has done so much for optical science. He built up the lens of separate rings, and the rings even of sepa-

rate pieces, in 1811; and thus what was carried into practice eleven years after by Fresnel, and has been considered his invention, is merely the application of the polyzonal lens of Sir David Brewster. These improvements, and the substitution of totally reflecting prisms by Alan Stephenson, for reflectors previously employed with the new dioptric apparatus, seem to leave nothing more to be desired in this department of light-house construction. But, like other valuable discoveries and inventions, that of Sir David Brewster, notwithstanding all its advantages, came but slowly into use. France was the first to avail itself of so important a contrivance. In 1822 Fresnel built up a lens, and, as suggested long before by Sir David, used it in conjunction with mirrors in the lighthouse of the Tour de Cordouan. In 1834, in consequence of the recommendation of the House of Commons, a revolving light, on the same principle, was placed on Inchkeith, and a fixed light on the Isle of May.

The attention of scientific men, as far as lighthouses are concerned, is now almost confined to the discovery of the best mode of producing the light. That in ordinary use leaves little to be desired, when the weather is tolerably clear: since a first-class oil light, at the height at which it is usually elevated, is visible from the masthead when the vessel comes above the horizon of the lighthouse—the nature of our climate would not allow a greater elevation to be given to the lights. It is, therefore, in hazy weather that a more intense light becomes desirable. Science furnishes more than one such light. Among these is the Drummond Light, which possesses both advantages and disadvantages when applied to lighthouses—the preponderance of the one over the other not being, however, very decided; and the electric light, which may in time supersede all others on the mainland, especially if some of the inconveniences by which it is accompanied are removed, or even lessened. The necessity for a steam-engine, when it is employed, renders it inapplicable on rock stations, such as the Eddystone Lighthouse, and the Bell Rock.

In the employment of the electric light, two very important matters are to be considered: the production of the electricity, and its transformation into light. The most obvious mode of effecting the former would be the use of the galvanic battery: and, accordingly, numerous experiments have been made with that object. Among others, a most important series, in the central workshops of the Administration of Lighthouses in France from 1848 to 1857. So far as the mere production of an intense light was concerned, the success of these experiments was complete. But the expense of the battery was very great, and the irregularity of the results obtained was very

serious. It was therefore concluded that galvanic electricity is not suited to the purposes of lighthouse illumination.

Within the same period, a new mode of obtaining the electric light, founded on the production of currents by magnetic induction, was tried with great success. In 1853, Professor Holmes made experiments on the light obtained by means of electro-magnetic machines, which had been used by a Parisian company for the decomposition of water, with the object of its constituents being used for combustion, but, commercially, without success. The apparatus was imperfect; nevertheless, the results were very encouraging; and they became still more so when a better apparatus was used. Holmes's apparatus was tried at the South Foreland lighthouse, in 1859: and its performance was favourably reported on by Mr. Faraday. But, after some time, its use was discontinued there, because it was considered that the light produced by it might, on account of its great intensity, be visible when other lights on the same coast would no longer be perceptible, through foggy weather: and that vessels might thus be fatally led astray.

With a magneto-electric machine, the electricity is obtained by causing soft iron, round which insulated wire has been coiled, to revolve in front of one or more permanent magnets. The inductive action of the permanent magnets causes temporary magnetism in the electro-magnets, constituted by the soft iron on which the insulated wire has been coiled. For, as the circulation of electric currents around soft iron causes it to be magnetized, so the magnetization of soft iron causes the circulation of currents round it, and therefore in the insulated wire coiled upon it. When it approaches the permanent magnet, a current in one direction is generated; and when it recedes from it, and returns to its natural state, a current in the opposite direction. A very simple contrivance, called a *commutator*, causes both currents to proceed in the same direction, and therefore to produce a combined effect: and these currents may be called into existence so rapidly, as to render the light emitted by them, so far as our senses are concerned, continuous and uniform.

It is obvious that the production of light, in this way, is merely an example of the correllation of the physical forces, and of a change of the imponderables, successively, one into the other. Luminous calorific and actinic rays, emitted by the sun—it cannot ever be conjectured how long ago—were absorbed by the vegetable which gave rise to the coal: these, in the furnace of the steam boiler, are liberated in the form of heat: this heat is changed by the steam-engine into motion: this motion is changed into electricity by the magnet: and this

electricity is restored to its original form of light, in its passage between the charcoal points of the electric lamp. It is equally easy to trace the changes which take place, when the motion of the magneto-electric apparatus is produced by muscular force, instead of by the steam-engine.

It is not necessary to use permanent magnets, in the development of electricity by means of induction. Recent experiments by Mr. Siemens show that the permanent magnets may be replaced, in such experiments, by electro-magnets. And he even believes that such a substitution would be advantageous, under the supposition that the permanent magnets become impaired in power, by use in this way. But both the French and English official experiments on the applicability of the electric light to lighthouses, have shown the contrary to be the fact.

Wilde's magneto-electric machine is intermediate between the ordinary magneto-electric machine and that suggested by Siemens's experiments. It is constructed on a principle long since brought forward by M. Seguin the elder. In Wilde's apparatus, electricity is produced by permanent magnets, in an armature which is an electro-magnet of a peculiar form, and is made to revolve rapidly. The electric current, thus generated, in the armature, is used to excite a system of electro-magnets; and these develope a more intense current in a second electro-magnetic armature, which also revolves rapidly. This second current is used to excite a second system of electro-magnets; and these develope a still more intense and extremely powerful current in a third electro-magnetic armature; which, like the others, revolves rapidly. Each armature makes about three thousand revolutions in a minute; and it is the wear and tear which must arise from heavy masses moving with so high a velocity that constitutes the great objection to this very ingenious and most powerful machine.

Mr. Holmes's apparatus was transferred from the South Foreland to Dungeness, in 1862. It was fixed over an oil lamp apparatus, lest any accident should render it incapable of being used. The Elder Brethren of the Trinity House refuse to sanction the use of the electric light, unless when, in case of its failure from any cause, it can be instantly replaced by the ordinary oil apparatus. Moreover, with the electric light, a duplicate of every portion of the apparatus is required, lest any of it should get out of order.

The apparatus at Dungeness consists of one hundred and twenty permanent magnets of about fifty pounds each, ranged on the periphery of two large wheels. One hundred and sixty soft iron cores, surrounded by coils of insulated wire, are made to revolve past the magnets one hundred times in a minute, by steam power. The streams of electricity, thus produced, are

collected together by means of a commutator, the alternate positive and negative currents being brought into one direction. The combined current is conveyed, by a thick wire, from the engine-house to the illuminating apparatus, where it forms a continuous and brilliant spark between two charcoal points, which are maintained at a proper distance apart by means of a balance arrangement, and an electro-magnet, round which the wire coils. The charcoal points are consumed in about three hours and a half; after which period they are changed, without extinguishing the light, as it is the kindling of the second pair which puts out the first. In more recently constructed machines, a smaller number of magnets and soft iron cores are employed.

At the close of 1859, experiments were commenced by the French Lighthouse Engineers, with an electro-magnetic machine obtained from the Alliance Company. This apparatus consisted of fifty-six magnets, distributed in seven equidistant planes, on the angles of a right octagonal prism. The electro-magnetic armatures, which were fixed on discs turning round the axis of the prism, and were made to revolve by a steam-engine of two-horse power, passed between the groups of magnets. The alternate currents were brought into the same direction, and united into one, without a commutator. Sixteen changes of direction corresponded to every revolution of the disc; and a maximum of intensity was obtained, when the machine made about four hundred revolutions in a minute; in which case, the current was reversed six thousand four hundred times in a minute.

The electric lamp, which was used with these experiments, is so contrived as that the charcoal points approach each other, according as they are consumed, without, in any case, coming into contact. When they are at the proper distance apart, two forces, one derived from a spring, the other from an electro-magnet, the coil of which is traversed by the current, balance each other, and the points remain at rest; but when, on account of increased distance between these points, the power of the current is diminished, the spring comes into action, and causes the points to approach, until their motion is stopped by the restoration of energy to the electro-magnet. This apparatus may be adjusted to the power of any given current; and, notwithstanding its delicacy, it has been found to work with great precision. Much, however, depends on the nature of the charcoal points; those made from the deposit on the interior of gas retorts, and obtained in commerce, do not give complete satisfaction, and it is not easy to obtain others of a better kind, and quite free from objection. The want of homogeneity in the charcoal causes constant variations in the light, however

uniform the electric current may be. The same injurious effect is produced by very slight alterations of the distance between the points, and by changes of the luminous arch from one side of the points to another, an occurrence which sometimes takes place. A slight displacement of the focus would throw the rays too high, or depress them too low. No displacement, however, greater than five millimetres, has been observed, which would raise or depress the bundle of rays only through two degrees; and the light sent from the lighthouse to the horizon would still be in excess of that from the very best oil apparatus. A report was made to the French government, regarding these experiments, in 1863.

Two magneto-electric machines have been placed in the double lighthouse on the Cap de la Hève; and other nations are following the example of England and France, in attempting the introduction of the electric light into lighthouses.

The reports made to both the English and French governments, on the application of the electric light to lighthouses, in a great degree coincide, and they enable us to form a very fair idea of the advantages and disadvantages which attend its use. Both agree in the assertion that there has not yet been time to form a final judgment regarding the matter.

Nothing can exceed the brilliancy of the electric light; no other light can compete with it. Faraday estimates its power at eight times that of a first-class ordinary light; and he found that it was comparable with that of the sun, when both were seen together. When seen with the ordinary oil light, the extinction of the latter produced no perceptible diminution of effect, nor its being re-lighted, any augmentation. The peculiar bluish tint of the electric light is rather an advantage, since it causes it to be more easily distinguished from other lights. But it may be made of any colour, and intermittent, according to any law. Its capability of being instantaneously extinguished, and re-lighted, at pleasure, would enable it to be used on parts of the coast where, on account of the difficulty hitherto experienced, of producing lights easily distinguishable, it has not been found advisable to erect lighthouses. The same property also fits it well for signalling; and it would be very easy to make any lighthouse in which it is used, tell its own number, by means of certain periodical extinctions. It is entirely free from the enormous shadow cast by the oil apparatus, its descending rays being unabsorbed.

The intensity of the electric light is not, however, so great an advantage as might, at first, be supposed. The oil light now in use can, as we have said, be seen quite as far, in fine weather; and in fogs, sufficiently dense to hide the sun, both become invisible. But, when it ceases to be visible, the engine

required for obtaining it may be turned to good account in bell-ringing, and the production of other sounds much louder, and therefore audible to a much greater distance, than those which are possible with the means at present employed.

It is only in intermediate states of the atmosphere that the electric light has advantages over the ordinary light. At other times, its intensity is considered by the French engineers, even as a disadvantage, since it causes the eye to be dazzled, and therefore renders it incapable of seeing distinctly. Comparisons have been made between it and a first-class oil light, in hazy states of the atmosphere; and it has been found that its advantage rapidly diminishes as the state of fog is approached. But, with the electric light, the greatest power of the rays may be directed a little below the horizon, so as to give more intensity to the plunging rays; which is impossible, with the ordinary light, without reducing the distance at which it will be visible. And the necessity for having a duplicate steam-engine makes it easy, without much additional expense, to double the power of the apparatus, which increases the penetrative capability of the light. Thus, when an electric light, of a given power, in a given state of the atmosphere, will be visible for the distance of not quite sixteen kilometres, a light of double the power will be visible, in the same state of the atmosphere, for more than seventeen kilometres. The light of a first-class oil apparatus, in the same circumstances, would be visible only for the distance of about thirteen kilometres.

The optical apparatus required by the electric light is less expensive than that which must be used with a light of the ordinary kind. The optical apparatus must, in every case, bear a relation to the light in its focus; and the oil light is far larger than the electric. With the ordinary optical apparatus, the electric light would not have sufficient divergence; and the rays would be thrown into the form of a ring, either whole or broken. When an oil light requires an optical apparatus 1·84 met. in diameter, one 0·30 met. in diameter will be large enough for the electric light. If, therefore, a new lighthouse is to be erected, there will be, with the electric light, a great saving in the item of optical apparatus; but, if the electric light is to be substituted for the ordinary oil light, the augmentation of expense, attendant on its use, will be considerable.

The cost of the electric light, both in its application and maintenance, is very serious; though not sufficiently so to justify its rejection, should it be found, in other respects, advantageous. The Elder Brethren of the Trinity House state that the cost of the apparatus which it requires, and even the maintenance of the light, far exceed those of an ordinary dioptric light of the first order. The apparatus at Dungeness

cost £6,626 6s. 3d.; and the annual expense of maintaining the light is £724 16s. 4d. But they admit that, as yet, no definite opinion can be formed on this point. In the report made to the French government, it is stated that, when a first-class lighthouse is to be erected, the cost will be considerably less, if the electric light is used; that, if the electric light is merely substituted for an oil light, there will still be a saving, though not to such an extent; and that the cost of maintaining the electric light is far less than that of maintaining an ordinary oil light. There can, however, be no doubt that the necessity for keeping duplicates of the apparatus, including even the steam-engine and boiler, and an oil apparatus, all ready to work at a moment's notice, as required by the Trinity House, must seriously augment the expense, both of first construction and maintenance. The complexity of the apparatus increases the liability to derangement, and the cost of repairs. It can be worked only by men of a superior class, and, therefore, who demand higher pay than the ordinary lighthouse employés. The engineer, especially, who keeps the apparatus in order, must be such a person as cannot always be had; and in the case of misconduct, sickness, or death, it might be difficult to replace him, particularly at remote stations. But there is nothing to prevent one engineer from having charge of several neighbouring lighthouses.

The last consideration to which we shall direct the attention of our readers, is the most important of all—the reliability of the electric light. If it cannot be entirely depended on, it can never come into general use for lighthouses. It has, indeed, attained a certainty and steadiness that has given entire satisfaction to the Elder Brethren; nevertheless, they insist on precautions in using it, which add very much to the expense. In justification of their strictness, in this regard, it must be admitted that, both in this country and on the continent, the electric light has occasionally gone out, and, in some instances, for not inconsiderable periods of time. In most cases, but not all, these interruptions have arisen from neglect on the part of those in charge of the apparatus; but this is precisely a source of failure which it will always be most difficult effectually to guard against. The management must necessarily be carried on in two places—the engine-room and light-room. In the former there is great danger of disarrangement, or neglect; in the latter, there can be no absolute security against some unfortunate accident. The electric lamp now in use, is, it is true, very certain in its operation; but it is of extremely delicate construction, and cannot, without risk of derangement, be committed to the charge of inexperienced and unskilful persons.

It must be borne in mind, in weighing the advantages and disadvantages of the electric light, that no new contrivance has ever been rendered perfect, at once. For any other purpose but that of a lighthouse, the electric light is sufficiently reliable; and it is only because the slightest interruption of the light, in a lighthouse, would be fraught with the most imminent peril to life and property, that extraordinary precautions are deemed necessary by the Trinity House—precautions which are rarely justified by an actual failure of the electric light, but which, from its possible occurrence, are indispensable.

Should improvement advance so far, that the electric light will become entirely reliable, which, however, seems very improbable, if not impossible, duplicates of at least the more solid portions of the apparatus might be dispensed with, and an oil apparatus, in conjunction with the electric, would not be required. The cost of the electric light would then, most probably, be less than that of the ordinary oil light; while the advantages it would secure would make it greatly preferable to any other light that could be applied to lighthouses.

THE LOW BAROMETER OF THE ANTARCTIC TEMPERATE ZONE.

BY RICHARD A. PROCTOR, B.A., F.R.A.S.

THE great difficulty presented by the science of meteorology lies in the intricate combination of causes producing atmospheric variations, and the impossibility of determining, by experiment, the relative efficiency even of the most important agents of change. As Sir W. Herschel well observed, we are in the position of a man who hears at intervals a few fragments of a long history narrated in a prosy, unmethodical manner. "A host of circumstances omitted or forgotten, and the want of connection between the parts, prevent the hearer from obtaining possession of the entire history. Were he allowed to interrupt the narrator, and ask him to explain the apparent contradictions, or to clear up doubts on obscure points, he might hope to arrive at a general view. The questions that we would address to nature, are the very experiments of which we are deprived in the science of meteorology."*

It is, therefore, but seldom in the study of this science that we meet with phenomena to which we can assign a definite

* Kaemtz's *Meteorology*.

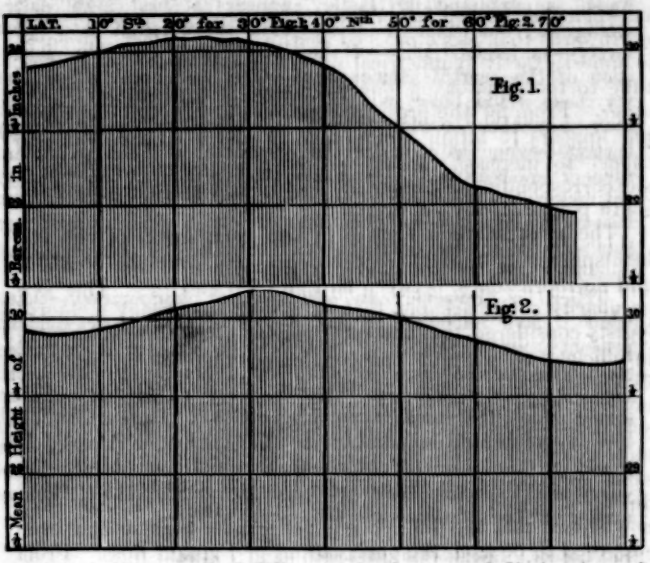
cause, or which we can explain on simple principles. Even those marked phenomena which appear most easily referable to simple agencies, present difficulties on a close investigation, which compel us at once to recognize the efficiency of more causes than one. For instance, the phenomenon of the trade-winds, as explained by Halley, appears at first sight easily intelligible; but when we look on this phenomenon as a part merely—as indeed it is—of the marvellously complex circulation of the earth's atmosphere—when we come to inquire why these winds blow so many days in one latitude, and so many in another, or why they do not blow continually in any latitude—when we consider the character of these winds as respects moisture and temperature, the variation of the velocity with which they blow, and of the quantity of air they transfer from latitude to latitude—we encounter difficulties which require for their elucidation the comparison of thousands of observations, or which baffle all attempts at elucidation.

There is, however, one atmospheric phenomenon—that which I have selected for the subject of this paper—which presents a grand simplicity, rendering the attempt at a simple solution somewhat more hopeful than is usually the case with meteorological phenomena. The discovery of this phenomenon formed one of the most interesting results of Captain Sir J. C. Ross's celebrated expedition to the Antarctic Ocean. He found, as the result of observations conducted during three years, that the mean barometric pressure varied in the following manner at the latitudes and places specified:—

South latitude.		Height of the barometer.	Place.
0°	0′	29·974 in.	At sea.
13	0	30·016	—
22	17	30·085	—
34	48	30·023	Cape of Good Hope & Sydney.
42	53	29·950	Tasmania.
45	0	29·664	At sea.
49	8	29·469	Kerguelen & Auckland Isles.
51	33	29·497	Falkland Isles.
54	26	29·347	At sea.
55	52	29·360	Cape Horn.
60	0	29·114	At sea.
66	0	29·078	—
74	0	28·928	—

We see here a gradual increase of barometric pressure from the equator to about 30° south latitude, and from this point at first a gradual diminution—so that in about 40° south latitude we find the same pressure as at the equator, and thence a more rapid diminution. The rate of change is illus-

trated graphically in Fig. 1, which represents the height of the barometer above 28½ inches for different southern latitudes. In the northern hemisphere there is a similar increase of pressure as we leave the equator, a maximum is there also attained in about latitude 30°; but from this point towards the



poles there is a marked difference in the rate of diminution of pressure in the two hemispheres. The following table by Schow is sufficient to indicate this:—

North latitude.	Barometric pressure.
0°	29·853 in.
10	30·002
20	30·004
30	30·069
40	30·006
45	30·011
50	29·943
55	29·960
60	29·835
65	29·623
70	29·722
75	29·863

There are minor irregularities in this table, due, doubtless, to local peculiarities, the arrangement of land and water being

so much more complicated in the northern than in the southern hemisphere. Neglecting these (as in Fig. 2, which represents for the northern hemisphere the relations corresponding to those exhibited for the southern hemisphere in Fig. 1), we see that there is a much greater resemblance between the rise and fall of barometric pressure as we proceed northwards than as we proceed southwards. In fact, the curve is almost exactly symmetrical on either side of 30° north latitude to the equator on one side, and to latitude 60° on the other. From 60° the pressure continues to diminish for awhile, but appears to attain a minimum in about latitude 73°, and thence to increase. In the southern hemisphere, if there is any corresponding minimum, it must lie in a latitude nearer the south pole than any yet attained.

The most marked feature in the comparison of the two hemispheres is the difference of pressure over the southern and northern zones, between latitudes 45° and 75°. This is a peculiarity so remarkable, that for a long time many meteorologists considered that the observations of Captain Ross were insufficient to warrant our concluding that so important a difference really exists between the two hemispheres. But not only has Captain Maury—from a comparison of 7000 observations—confirmed the results obtained by Ross, but, in meteorological tables published by the Board of Trade, the same conclusions are drawn from 115,000 observations, taken during a period of no less than 13,000 days. In fact, it is now shown that the difference is yet greater than it had been supposed to be from the observations of Captain Ross. From a comparison of observations made in the Antarctic Seas with those of Captain Sir Leopold McClintock, it appears that the average difference of barometric height in the northern and southern zones, between latitudes 40° and 60°, is about one inch. Figs. 1 and 2 exhibit a relation midway between these later results and those tabulated above.

Assuming an average difference of only three-quarters of an inch in the northern and southern zones, between latitudes 40° and 60°, let us consider what is the difference of pressure on these two zones of the earth's surface. The area of either zone is 21,974,260·5 square miles, and the pressure on a square mile due to a barometric height of three-quarters of an inch is about 670,000 tons, therefore the pressure on the northern zone, between the latitudes named, exceeds the pressure on the southern zone by no less than 14,500,000,000,000 of tons. Including all latitudes within which there has been ascertained to be a difference of barometric pressure in the two hemispheres, we shall probably be within the mark if we say, that the atmospherical pressure on the northern hemisphere is

20,000,000,000,000 tons greater than the atmospherical pressure on the southern hemisphere.

Such a peculiarity as this may almost deserve to be spoken of in the terms applied by Sir J. Herschel to the distribution of land and water upon our earth, it is "*massive* enough to call for mention as an *astronomical feature.*" I propose to examine two theories which have been suggested in explanation of this feature of the earth's envelope. These theories are founded on *local* peculiarities, and the feature considered appears as a *dynamical* one—that is, as a peculiarity resulting from states of motion in the aërial envelope. I shall endeavour to establish a theory founded on a consideration of the earth's mass *as a whole*, and presenting the atmospheric feature in question as a *statical* one.

The first theory I have to notice is one founded on the configuration of land and water upon the northern and southern hemispheres of the earth's globe. In the northern hemisphere, and more especially in that part of the northern hemisphere in which barometrical observations have been most persistently and systematically conducted, there is much more land than in the southern hemisphere. Now barometrical observations are referred to the sea-level, and observations made in Europe and America may be considered as referred to the level of the northern parts of the Atlantic Ocean. It is argued that the North Atlantic, compared with southern oceans, is little more than "a large lake, having elevated banks east and west." "Practically, the air there is a portion of the solid globe, so that the unconfined air will rest upon and rise above the former, as if it were solid and a portion of the earth; so that the altitude of the air over the North Atlantic will be increased some hundreds of feet, and the barometer at the sea-level will be pressed upon, not only by the free air clear of the earth's banks, but also by the air confined in the basin, much as if the air were at the bottom of a mine."*

Presented in the above form, the theory that the higher northern barometer is due to the contour of the northern hemisphere scarcely deserves serious comment. To speak of the confined air of the North Atlantic Ocean is surely unreasonable. An ocean 2000 miles across, swept by more frequent storms than are experienced in any other part of the globe, cannot be very aptly compared to "the bottom of a mine." An inelastic fluid flowing steadily over a rugged surface shows no trace, or but the slightest trace, of the nature of that surface by any variations of its own level. But it is still less conceivable

* From a letter addressed to the editor of the *Athenæum*, by Dr. H. Muirhead.

that an elastic fluid should be influenced in the manner suggested. In fact, if this happened we should no longer be enabled to determine the heights of mountains by barometric observations; for according to the theory the air should extend to a greater height above mountains than above plains; and as regards comparison between a barometer at the foot of a mountain and one at the summit, we might argue that the barometer in the valley, compared with a barometer at the same level in a plane district, "is pressed upon, not only by the air clear of the mountain tops, but also by the air confined within the valley," so that the altitude over the valley is greater by some hundreds of feet than the altitude over a plain at the same level as the valley; and thus, before we could determine the height of the mountain above the level of the plain, we should have to determine the exact effects due to the confinement of the air in the valley. We know that, on the contrary, the average barometric pressure in the most confined valley does not differ appreciably from the average pressure over the most widely extended plain at the same level.

We may, however, reasonably inquire whether the presence of continents in the northern hemisphere might not operate in another manner. If we place any mass within a vessel containing fluid, it is clear that we increase the fluid pressure over every point of the vessel's bottom, because this pressure depends wholly on the depth of the bottom below the level of the fluid, and the level rises when any solid substance is placed within the vessel. Now if we suppose a globe covered all over by water to be surrounded by a perfectly uniform atmospheric envelope, the mean pressure of this envelope at the water-level would certainly be increased if continents were supposed to be raised in any manner above the surface of the water; and if the atmosphere over one half of such a globe were supposed to be prevented in any way from mixing freely with the atmosphere over the other half, then it is clear that the mean pressure at the water-level would be greatest on that half-globe over which the most extensive and highest continents had been raised. On the assumption, then, of some such arrangement over our own earth—an arrangement, that is, which should prevent the northern air from mixing with the southern—one might see in the northern continents a true cause of increased barometric pressure at the sea-level of the northern hemisphere.

We have, however, not only no evidence that such an arrangement exists, but very strong evidence of an atmospheric circulation which carries air from hemisphere to hemisphere, and mixes in the most intimate manner the whole mass of

gases which form the earth's atmospheric envelope. The whole question of the circulation of the air is investigated in Maury's interesting work on the *Physical Geography of the Sea*, and he appears to establish in the most convincing manner, the interchange of air between the northern and southern hemispheres.

And even if we could assume that the atmospheric covering of any portion of the earth's surface was in any way prevented from passing freely to other regions, yet the cause assigned would be inadequate to account for the difference of barometric pressure actually existing between the two hemispheres. All the land above the sea-level in the northern hemisphere, if uniformly distributed over the surface of that hemisphere would be raised to a height of less than 200 feet above the present sea-level, and the actual difference of level corresponding to the observed difference of barometric pressure is more than four times as great.

Passing over this theory as neither consistent with the known laws regulating the motions of elastic fluids, nor sufficient even if the consideration of those laws were neglected, we come to the theory suggested by Captain Maury—a theory deserving of much more attentive consideration. I shall quote his own words, as the fairest method of presenting his theory; after stating the observed difference of a barometric pressure in the two hemispheres, and mentioning the expulsion of air from the northern hemisphere as the cause of this difference, he writes:—"To explain the great and grand phenomena of nature, by illustrations drawn from the puny contrivances of human device, is often a feeble resort, but nevertheless we may, in order to explain this expulsion of air from the watery south, where all is sea, be pardoned for the homely reference. We all know, that, as the steam or vapour begins to form in the tea-kettle, it expels air thence, and itself occupies the space which the air occupied. If still more air be applied, as to the boiler of a steam-engine, the air will be entirely expelled, and we have nothing but steam above the water in the boiler. Now at the south over this great waste of circumfluent waters, we do not have as much heat for evaporation as in the boiler or the tea-kettle; but, as far as it goes, it forms vapour, which has *proportionately* precisely the same tendency that the vapour in the tea-kettle has to drive off the air above, and occupy the space it held. Nor is this all. This austral vapour, rising up, is cooled and condensed. Thus a vast amount of heat is liberated in the upper regions, which goes to heat the air there, expand it, and thus by altering the level, causes it to flow off."

The theory thus divides itself into two parts: we have first

the expulsive effects due to the vapour raised from southern oceans; and, secondly, the expansive effects due to the liberation of heat as the vapour is condensed. Now I would, in the first place, submit that we cannot assign to the second cause the effects here considered. The amount of heat liberated as the vapours rising from southern oceans are condensed is undoubtedly great, but it cannot be more than the equivalent of the amount of heat rendered latent as the vapours are formed, and therefore the expansive effects due to the liberation of heat cannot be greater than the contrary effects due to the prior imprisonment of heat. It is quite true, and has been accepted as the undoubted explanation of many climatic effects, that if vapour be raised in one place and condensed over another, then the temperature of the air over the latter place is raised. But when we have to consider a phenomenon extending over a zone twenty or thirty degrees in width, we cannot argue in this manner. Nay, it is *necessary* to the force of Maury's second cause that the condensation of vapour should take place over the very zone in which the vaporisation is proceeding. To assign similar effects to both processes, is to require that the winding up and the loosening of the spring should take place in the same direction.

Whatever effects, then, are due to the constant evaporation going on in the southern hemisphere must not be derived from changes of temperature. So far as these are effective at all, they must depend on the excess of evaporation over condensation (since the excess cannot possibly lie the other way), and therefore represent diminution of heat or increase of pressure, the contrary effect to that we have to account for. We have, therefore, only to consider the first cause mentioned by Maury; that is the expulsive effects due to the formation of aqueous vapour.

At first sight, this process of expulsion appears simple enough, and seems further to coincide with many well-known phenomena. The theory supposes that over a wide zone of the southern hemisphere aqueous vapour is continually rising; that as it rises it displaces in part the heavier air over these regions; and that equilibrium being thus disturbed, the excess of air flows off continually towards the equator. Now we know that the prevailing surface-winds over that zone of the southern hemisphere in which the barometer exhibits the peculiarity we are considering, blow from the equator; that is, they tend to sweep the lower strata of the atmosphere towards the south pole. They therefore tend to increase the quantity of humid air in high southern latitudes. We know also that the prevailing upper currents over the southern zone we are considering, blow towards the equator. They tend, therefore,

to carry the drier portion of the air towards the equator. All this seems in accordance with Maury's theory, and, indeed, if the prevailing upper and lower currents flowed in directions contrary to those indicated, the theory would fall at once.

Again, although we find no evidence in barometric pressure over the south tropical zone of that increase which Maury's theory would lead us to expect (since the surplus air is carried first to this zone), yet it might be argued that the surplus is so distributed, as to appear in another way. It is evident that if the atmospheric envelope normally appertaining to the southern hemisphere were, through the effects of the causes assigned by Maury, increased in extent, this increase might show itself, not in an increase of pressure over the south tropical zone—that is, not in an increase of *height* there—but in the extension of the surplus atmosphere into the northern hemisphere. This would be shown by the extension of the southern trade-winds to or beyond the equator, so that the (so-called) equatorial zone of calms should lie north of the equator. As this is really the position occupied by the belt of calms, Maury's theory appears to gain additional force by the coincidence.

Another argument may be drawn from the analogy of the low barometer in moist weather. In fact, it is well known that Deluc explained this phenomenon in a manner precisely accordant with the views expressed by Maury.

Despite the apparent force of these arguments, and others that might be adduced, it will not be difficult, I think, to show that neither is Maury's theory consistent with known physical laws, nor (passing over this objection) is the theory *sufficient* to account for the grand phenomenon under consideration.

It is quite true that a volume of aqueous vapour weighs less than an equal volume of air; it is equally true that a volume of moist air weighs less than an equal volume of dry air *at the same tension*. But water, quietly evaporating in the open air, does not displace the air, but penetrates into its interstices, according to the well-established law regulating the mixture of vapours. The aqueous vapour which thus intimately mixes itself with the air produces no effect whatever, either by its weight, or by its elasticity, on the movements of the atmosphere. The experiments of Gay-Lussac, Dalton, and others, have long since proved that the actual effects of the quiet evaporation of water are those here described. It is on this account that Deluc's hypothesis in explanation of the fall of the barometer when the air is moist is now no longer accepted. It has been shown that the observed fall is not due to the moistness of the air, but to increase of temperature. Hot winds bring (in Europe) moist air, and thus moist air and a low barometer are found to be coexistent phenomena. But they are not in the

relation of cause and effect. In fact, in New Holland, where hot winds bring dry air, we find the barometer low when the air is dry.

It follows from what has just been said of the manner in which aqueous vapour associates itself with air, that atmospheric pressure is increased instead of diminished by the process of quiet evaporation, since the weight of the vapour is added to that of the air. Therefore, all things being equal, we should expect to find the barometer higher in the southern or watery hemisphere than in the northern.

It might seem unnecessary to consider Maury's theory further, but as some doubts may still remain whether some process of the kind conceived by him may not take place,* I proceed to consider the *efficiency* of such a process to account for the great phenomenon we are dealing with.

It must be remembered, in the first place, that the theory requires that there should be a greater volume of mixed air and vapour over the southern temperate zone, than there is in the corresponding northern zone, otherwise there would not be that continual overflow towards the equator which is required by the theory. So far as it goes, this increment of volume implies an increment of weight. The increase of volume is more than compensated (in theory) by diminution of specific gravity, but it must be held in mind that the increase of volume has to be accounted for by the theory *as well as* the difference in barometric pressure.

Again, the theory requires that the upper regions of air should be dry, for it is the upper air that is carried towards the equator; and if this air were moist, we should no longer have the different proportions of moist and dry air which are required by the theory. We *must* have an aggregation of moist air in high southern latitudes, and of dry air towards the equator.

Again, we must call to mind that one-half of the northern hemisphere is covered by water, and a part of the southern hemisphere is not so covered, so that the effects suggested by Maury are (1) not peculiar to the southern hemisphere, nor (2) do they prevail over the whole of that hemisphere.

Lastly, we must remember that the process conceived by Maury must be wholly or principally a diurnal process, and so

* In fact, Sir. J. Herschel, in his work on Meteorology, assigns as a cause of the low barometric pressure near the equator, compared with that near the tropics, a process similar to that conceived by Maury, only depending on the excess of heat near the equator. I cannot but agree with those meteorologists who consider that the notion of any appreciable *uplifting* of the air by the rising vapour of water is a mistaken one. But whether it be so or not, it is evident that Herschel's view would require a regular increase of pressure from the equator to the antarctic pole, and therefore is opposed to Maury's explanation.

can only take place (on an average) over one half of the southern zone at any one time.

All these considerations tend to diminish very importantly the efficiency of the cause assigned by Maury. Let us, however, consider what is the maximum value that efficiency could have if all these circumstances were neglected. We shall see that even in this case, which assigns an efficiency at least three or four times as great as would be consistent with actual facts, we shall still find the cause assigned by Maury inadequate to the production of the phenomenon under consideration.

The greatest weight of aqueous vapour which is ever present in a given volume of air is equivalent to about one-sixtieth part of the weight of the air. Now, if we suppose the barometer at thirty inches, and the whole column of air above the barometer to be impregnated with air in the above-named proportion—a view very favourable to the theory, since the cold of the upper regions of air largely diminishes the proportionate weight of aqueous vapour—it is clear that one-sixtieth part—or half an inch—of the barometer's height is due to the presence of aqueous vapour. Now, at mean tensions the specific gravity of aqueous vapour is about three-fifths of the specific gravity of air, so that the proportion of one-sixtieth part of weight corresponds to a proportion of one-thirty-sixth part of volume; in other words, our column of air owes one-thirty-sixth part of its height to the presence of aqueous vapour. If we suppose this thirty-sixth part to flow off—not from the upper regions only, but in such a manner that one complete thirty-sixth part of the volume of the column should pass off—then, instead of standing at a height of thirty inches, the barometer would stand at a height of 29½ inches, less by only one-third of an inch than the height of 29¼ inches due to the dry air alone. Now we cannot, in accordance with Maury's theory, legitimately add the five-sixths of an inch of barometric pressure to the height of the barometer under a neighbouring column. For we have no evidence to show that the air assumed to be expelled from the southern temperate zone is heaped over the southern tropical zone; on the contrary, we have a barometer in the latter zone not quite so high even as the barometer in the corresponding northern zone. Therefore if air is expelled in the manner supposed by Maury, it must be distributed over a very much greater portion of the globe's surface than it had been expelled from. Hence, returning to our imaginary column of air, but a small fraction of the five-sixths of an inch due to overflow must be added to the barometer under a neighbouring air-column. The latter barometer originally at 29¼ may be fairly assumed to rise at most to about 29½ inches. We

have, then, a difference of 29⅜—29¼ inches, or two-thirds of an inch; so that despite all the opposing considerations we have neglected, we still have a difference less by one-third than that for which we have to account; and, indeed, so far as the comparison between the northern and southern temperate zones is concerned (and this is the true question at issue), we are only entitled to consider the third part of an inch lost by overflow, as the true measure of the efficiency of this cause.

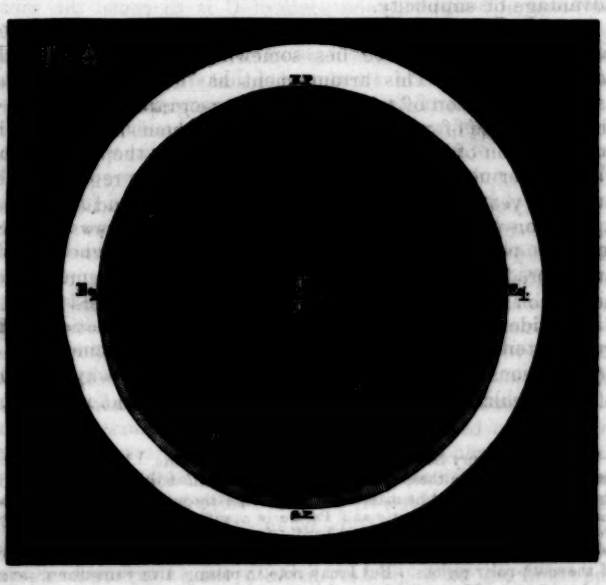
So far as I am aware, the theory I am about to present in explanation of the phenomenon of a low antarctic barometer, is original. It is sufficiently simple;—perhaps, if we remember how very seldom physical phenomena admit of a simple explanation, one may say that the theory labours under the disadvantage of simplicity.

It is obvious that the centre of gravity of the solid portion of the earth's globe lies somewhat to the south of the centre of figure. This arrangement has long been accepted as the explanation of two remarkable geographical features—the prevalence of water over the southern hemisphere, and the configuration of nearly all the peninsulas over the whole globe. Whether or not those parts within the antarctic regions which have not yet been explored, are occupied by land (chiefly) is a question which has little more bearing on our views respecting this point, than has the counter question—whether the unexplored north-polar regions are or are not occupied by a north-polar ocean.* Supposing these arrangements to exist, it is evident that they form mere local peculiarities. The general tendency of water towards the southern hemisphere is very obvious, and, so far as I am aware, no other explanation of the peculiarity has ever been offered than that founded on

* Captain Maury holds the affirmative on both points. I have already had occasion to discuss in these pages his theory of a *tidal* north-polar ocean, and I think the theory cannot be maintained. But the theory of a polar ocean communicating with the Atlantic and Pacific is a sufficiently probable one. The theory of an antarctic continent is hardly in the same position, since antarctic explorations have given us but faint indications, here and there, of the habitudes of the south-polar regions. But I may note, in passing, a very singular argument used by Captain Maury in favour of the existence of such a continent. He states it as a physical law that land is scarcely ever antipodal to land; "therefore," he says, "since the north-polar regions are probably occupied by a vast ocean, the south-polar regions are probably occupied by a vast continent." He seems to forget that it by no means follows that because land is seldom antipodal to land, water should seldom be antipodal to water. Since the extent of water is nearly three times that of land, it is absolutely necessary that nearly two-thirds of the water should be antipodal to water. The supposed peculiarity that nearly all the land is antipodal to water (one-twenty-seventh only being antipodal to land), is in reality no peculiarity at all. It would have been far more singular if any large proportion of the land (which occupies little more than one-fourth of the globe) had been antipodal to land.

a slight displacement southwards of the earth's centre of gravity. If, then, C is the centre of the black circle in Fig. 3, representing the solid part of the earth, the centre of gravity of this part lies (in the Fig.) slightly below C—between C and C′, let us suppose.

Now we see that, owing to this slight displacement, the watery envelope of the earth tends southward. If the earth were a perfectly uniform spheroid, it is clear that there would be a tendency to some such arrangement as is represented (on a greatly exaggerated scale) in Fig. 3, in which the shaded part represents the sea—that is, a shell of water, thicker towards the south, would surround the solid earth. For our present purpose it is sufficient to consider this supposed arrangement, as minor inequalities of the earth's surface-contour



have clearly nothing whatever to do with the phenomenon we are considering.

Let C′ be the centre of the spheroid which bounds the earth's fluid envelope. Then it is very clear that if this envelope were of the same specific gravity as the solid portion of the earth, the centre of gravity of the entire mass would lie very near C′, but slightly south of that point, on account of the slight southerly displacement of the centre of gravity of the solid portion. But when we consider that the specific

gravity of the fluid envelope is less than one-fifth of that of the solid globe, it is perfectly clear that the centre of gravity of the entire mass will not be so far south as C′. For, of the entire mass, the northern half is the heavier, and therefore the centre of gravity must lie north of the centre of the entire mass—that is, north of C′. In fact, it must lie much nearer to C than to C′.

Thus, the centre of gravity of the solid globe, and that of the entire mass, solid and fluid, both lie between C and C′. Now it is evident that the central point, about which the earth's atmospheric envelope tends to form itself as a spherical or spheroidal shell, is the centre of gravity of the entire solid and fluid terrestrial globe—that is, is a point north of C′. Therefore, precisely as the effect of the fluid envelope collecting itself centrally about a point *south* of C is to cause the mean depth of water to be greatest in the *southern* hemisphere, so the fact that the atmospheric envelope collects itself centrally about a point *north* of C′ should result in giving a greater mean depth of air (*referred to the sea-level*) over the *northern* hemisphere. This arrangement is represented in Fig. 3, in which the unshaded part is supposed to represent the atmosphere.

I have endeavoured to make the above explanation of my theory in explanation of the low antarctic barometer as complete and exact as possible; but there is another way of presenting the theory which, though less complete, may appear clearer to some minds:—

Variation of mean barometric pressure, as we proceed from one place to another, may be due either to a variation of circumstances of heat, moisture, and other like relations, or to a difference of level. Maury's explanation assigns to the low antarctic barometer a cause or causes falling under the former category. My theory amounts to the supposition that the low barometer is due to an absolute difference of level. I say that the sea-level, to which we refer barometric pressure, is *not* a just level of reference when atmospheric pressure over the whole globe is the subject of inquiry, because the southern seas stand out to a greater distance than the northern seas from the true centre of gravity of the earth's solid and fluid mass.

Assuming my theory to be correct, we have a means—rough, it may be, but not uninstructive—of determining the displacement of the centre of gravity of the earth's solid mass from the centre of figure. For, accepting one inch as the difference of barometric height at the two poles, it is easily calculated that this difference amounts to a difference of level of about 850 feet. In other words, the surface of the water at

S. P. lies farther than the surface of the water at N. P. from the centre of gravity of the entire fluid and solid globe by about 850 feet. Hence this centre of gravity must lie about 425 feet north of C′ (which is the centre of the bounding surface of the water). Now, it is evident that both the centre of gravity of the entire fluid and solid mass, and that of the solid mass, must lie much nearer to C than to C′. Hence both these centres of gravity lie considerably within 400 feet of C, and C′ lies considerably within 825 feet of C. Thus the centres of figure and the centres of gravity of the earth's solid mass, and of the entire fluid and solid mass, are collected within a space less than one-eighth of a mile in length—a distance almost evanescent in comparison with the dimensions of the earth's globe.

A RAMBLE IN WEST SHROPSHIRE.

BY REV. J. D. LA TOUCHE.

We left our tourist on the top of the Stiperstone range of hills, beholding a scene of mingled wildness and fertility, combined with considerable antiquarian and geological interest.

Pleasant, indeed, is that remote region in the long summer days, where, knee-deep among the heather and whinberries, you pick your steps, sometimes not without trouble, by the path stretching along the ridge from one to the other of the picturesque masses of rock, over thickly-strewn fragments of quartz, glittering like frosted silver in the rays of the sun; and pleasant it is to recur, even in thought, to a scene so removed from the "windy ways of man," and where you can muse in perfect quietness on the miracles of nature around.

But we must not leave our traveller here; there is much work before him if he is to dive into the mysteries of the thickly-bedded strata of the Llandeilo rocks, and when he has satisfied himself of the state of things in the primæval world, when trilobites and other creatures which have long passed away, inhabited the dreary, silent wastes, he will find ample occupation in tracing the manners and customs of his own species, in the vestiges they have left behind them—the races who have, from time to time, lived in these now sequestered valleys, and, attracted by their mineral treasures, pursued their earnest search for wealth into the very heart of the earth itself.

Our tourist now surveys, for the most part, that important subdivision of the Lower Silurian rocks, called the Llandeilo.

The Stiperstone range, upon which he stands, is pronounced by Sir R. Murchison to be the equivalent of the Lingula flags of North Wales; and as he would find no perceptible difference in the inclination of these two strata (the Lingula and the Llandeilo) in this neighbourhood, both dipping at an equally high angle towards the west, he might at first be led to suppose that they succeeded each other in point of time, as they do in position. There is, however, reason to believe, as Professor Ramsay has pointed out, that a stratum of great thickness, called the Tremadoc slates, was deposited between the era of the Stiperstone formation and that of the overlying Llandeilo flags. It would be impossible here to repeat all the reasons which the professor has set forth in his most interesting and instructive paper on "Geological Breaks," as leading him to this conclusion. But it will be of interest to state the circumstances under which, according to him, such breaks occur, since the geologist has frequent opportunities of witnessing instances of them on a minor scale; indeed, every section of a gravel and sand-pit furnishes illustrations of them.

The omission of such a stratum as this, found elsewhere, must, he says, arise from one of three causes: either, 1, the lower rocks were, at the time of its deposition, raised above water in the particular spots where it is omitted, and only submerged when it had been completed; 2, the deficient stratum may, indeed, have been deposited over the entire area, but was subsequently in parts washed away or denuded; or, 3, it may have been deposited in some parts, and not in others. Instances illustrative of the two latter of these causes are seen in every river deposit. The stream, sometimes diverted from its ordinary channel by the impetus it receives in a high flood, deposits a quantity of debris from high grounds in places where there had been but little previously, while in others it carries off the sand and stones which had been deposited. Of course, illustrations of upheaval can only be studied on a large scale; but it is possible, by attentively observing the layers of gravel so often exposed to view in a river bank or quarry, to arrive at a solution of some very interesting geological phenomena relating to this subject; and this study I would specially commend to persons who live far removed from the more striking manifestations of geological disturbances, in uninteresting (as they are called) and level countries, where, from the nature of the ground, the slow and sluggish streams wend their way, or on the sea-shore, where over banks of sand and mud, each ebb and flow of the tide leaves its own deposit, or carves out and modifies those previously made.

Here, on a stupendous scale, it is believed that some such

process must at one time have gone forward. Between the deposition of the Lingula flags of the Stiperstones, and the Llandeilo, which overlie them so regularly that there is nothing in this neighbourhood to suggest that they are not one stratum, there is believed to have been an enormous interval of time, since their fossils are widely different. Well, in North Wales are found strata which, judged by their fossil contents, are the equivalents of those of the Stiperstone rocks, and again strata equivalent to the Llandeilo; but between them a huge slice, called the Tremadoc slates, with fossils of a character intermediate between those of the strata above and below it. It is, therefore, to be presumed that this slice is the representative of a vast cycle of change in the organic life of these regions, of which no vestige whatever is left in the neighbourhood we are now examining—a missing link in the development of organic life is found, and a problem solved which would otherwise be inexplicable. But, still further, we are taught the important lesson of caution in our deductions from observed phenomena. It might have been inferred, from the sudden change in the organic life displayed by these successive strata, that its progress was capriciously interrupted and its character suddenly changed at a certain epoch; but this discovery of the Tremadoc slates with their intermediate fossils, is an additional reason to believe in that gradual, progressive development of species which so many other lines of research would seem to affirm; and it, moreover, shows that when, in studying other parts of the great geological volume, we might occasionally be led to suppose exceptions to this great law, such a conclusion may arise from some other missing links, some other pages, or even entire chapters, having been torn rudely from the venerable record.

At last we are prepared to descend through one of the numerous gorges, dingles, or cwms (as they are sometimes locally called) which penetrate these strata, running into them from the west, and exposing the Llandeilo rock, dipping at a very high angle towards the same quarter. Their thickness has thus been estimated at not less than 3000 feet. For the most part they are barren of fossils, except at the very top or the very bottom of the beds; to use the familiar illustration of my friend Mr. Salter, like a thick piece of bread well buttered on both sides. It will be understood that the bottom strata constitute the high hills which we have just left, and the higher are found in the valleys upon which we are now entering. As I stated before, the only spots in which I am aware of fossils being found are the little hollows on the high grounds formed by the sheep for shelter. There are other places mentioned in Sir R. Murchison's *Siluria*, such as Lord's Hill, near the Chapul;

but I have not been so fortunate as to hit on the exact spot. Indeed, I recommend those who explore this region to be moderate in their hopes of making a collection of fossils. Some spots of extraordinary richness are occasionally found, from which it is possible to carry off a profusion of capital specimens in an excellent state of preservation; but you may examine many a dreary cubic yard, or, I might even say, cubic mile of rock, without being repaid by a single fossil. A couple of summers ago, I was applied to by a gentleman, who professed to be an ardent collector, for some information as to the best localities in which to look for fossils; and having given him as accurate directions as I possibly could, he started on a three days' tour through the district. But when he returned, the whole of his spoils were contained in his waistcoat-pocket. This may appear discouraging, but it must not be supposed that all are equally unfortunate; on the contrary, some of my most satisfactory fossil-hunting days have been spent among the Llandeilo flags. I shall not attempt to enter upon the large subject of the fossils to be obtained here, since, to do it justice, it would be necessary to copy largely from Sir R. Murchison's important work; armed with which, no one can be at a loss to ascertain and classify his spoils. Suffice it to say, that they consist chiefly of tribolites of various kinds, orthoceras, and lingulas, interspersed with a few bivalve shells.

The most interesting feature in the lithological character of the rocks of this neighbourhood, is the occurrence among them of several layers of what Sir R. Murchison describes as "felspathic aglomerates and ash beds, or volcanic grits, as well as slaty porphyries, with crystals of felspar. Some of them alternate in ridges with the schist containing tribolites, others constitute courses of a few inches thick only, and occasionally include fragments of *Ogygia Buchii*. Organic remains are also found in beds composed almost exclusively of igneous materials, thus showing that volcanic action was rife at the sea bottom in which these lower Silurian strata were accumulated." And to account for these facts, that is, for the alternate layers of shale and felspathic rock, he supposes that these gritty beds were formed of the debris of submarine volcanoes. In recent times such have occurred, of which Graham Island, in the Mediterranean, is an instance. A cone of ashes and other volcanic products is formed, and is pushed upwards to a considerable height above the surface of the sea; subsequently it is attacked by the waves, and the scoriæ of which it was composed is spread out over the sea bottom. This in time is covered by the deposit of mud which, under ordinary conditions, is ever going on. A fresh eruption, and another cone would supply a second layer of felspathic ash, and so on

till, as in this neighbourhood, some six or eight would be formed.

With all respect for the illustrious propounder, if not the author of this theory, a tourist may be excused if certain questions suggest themselves to his mind before he can admit it, as a completely satisfactory solution of the problem; and when he considers that the opinion of geologists, as to what are, and what are not really volcanic rocks, has of late years been considerably modified, he may desire to know something more of these "felspathic ashes," their composition, history, and origin, before deciding the question. It is certainly very striking how frequently in rocks of this age, these alternate layers of shale and grit occur. At the Briedden they are conspicuous, and Sir R. Murchison describes them as occurring in "The rocky tracts extending from Llandegley and Llandrindod by the hills of Gelli Gilwern, and Carneddan to Builth," at Festiniog Tom-y-bwlch, and Cader Idris, etc. The occurrence, however, of somewhat similar alternations in other strata, though not perhaps so distinct and striking as they are here, may lead some to conclude that a more general law may be found to account for them, and that possibly they may only be another instance of that segregative force which we have had occasion to remark upon already—a force dividing the elements of these primeval rocks into their constituent parts, the clay separating itself into distinct beds, and the gritty and the more crystallizable materials also uniting into a stratum. Possibly this very tendency to crystallization may be the prime mover in the whole process, just as, to use a familiar illustration, it will cause the sugary portions of a pot of jam which has been kept long enough, to segregate into a layer distinct from the less crystallizable portion.

The Llandeilo rocks are succeeded, according to the opinions of the best geologists, by the Caradoc, or Bala series. These are largely exhibited on the east of the Longmynd, *i.e.*, in the Caradoc, and the country to the north and south of that striking hill, but are not found on the west, where the Llandeilo are immediately succeeded by much more recent rocks, such as the Wenlock shale, the intervening strata being omitted.

That there is a real distinction between the Caradoc or Bala beds, and the Llandeilo beneath them, there seems to be reason to doubt. Professor Ramsay says, "The community of the ordinary species of fossils in the Llandeilo and Caradoc or Bala beds induces me to treat them as one group;" and Sir R. Murchison himself speaks very cautiously about their separation, saying, "It is not pretended that a line can anywhere be precisely drawn upon a map between these strata." And,

accordingly, he has in the map which accompanies his work, shaded off the colour which indicates the one into that of the other, in that part of Montgomeryshire, where, as he believes, a distinction may be observed between the two. No doubt the fossils found in the two strata, as represented on each side of the Longmynd, are widely different, at least specifically, yet they may not be more so than might be expected in the upper and lower members of a stratum of such enormous thickness as this appears to be. If this be so, we may consider the rocks on this western side of the Stiperstone and Longmynd range, rising up as they do at a high angle towards the east, to be the continuation of a vast arch, of which the other extremity is the Caradoc and neighbouring hills, the great centre of upheaval being along the axis of the Longmynd.

This sketch of the geology of this district would be incomplete without drawing attention to a much more recent formation, which is very well displayed in some portions of it. This is the Llandovery, elsewhere divided into two members, the upper and the lower, but of these the former alone has left any traces here; it is in all these cases, however, seen to rest on very much older rocks, unconformably. Near Norbury it reposes directly on the Llandeilo, and it has left a small patch here and there (as will be seen by reference to the geological maps) in the great valley of Llandeilo, which we have been exploring; but at the southern extremity of the Longmynd, and along a considerable portion of its eastern flank, it rests on the much more ancient Cambrian, bearing a strong resemblance to a sea-beach.

These facts suggest, that between the times of the deposition of these strata a great change had taken place in the level and position of the underlying rocks, and it has been suggested as probable that the Longmynd, at the time of the formation of the Llandovery, presented the appearance of an island. It is here interesting again to notice the coincidence of a great change in organic life, with these evidences of a very long interval between the two formations. Out of the prodigious number of fossils found both in the Caradoc and the Llandovery rocks, only twelve species are known to be common to both. When we contemplate these strata, resting as they do upon the highly inclined rocks of the Longmynd, the mind is irresistibly carried back to reflect on the history of this region. There was at first a period during which the 26,000 feet of the Cambrian was forming; then another, during which the Lingula flags of the Stiperstone range were deposited. Then there was a vast interval, perhaps of subsidence, represented by the Tremadoc slates. Then again fresh deposits commenced over the entire area, and 3000 feet of Llandeilo

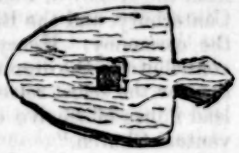
flags were formed; after which, possibly, that great upheaval took place, during which a mighty fault along the Stretton Valley, estimated by Professor Ramsay at 2000 feet, was effected, and the strata of the Longmynd reared up into an almost perpendicular position, as may be seen around Church Stretton. Then came a long period of denudation, such as is at this moment going on over the whole surface of the country, by which the frost, the rain, and other atmospheric agencies are incessantly wearing down the whole surface, and carrying it off in rivers to the sea. Then, and not till then, were the Llandovery conglomerates deposited on the denuded edges of the previous rocks, since which there has been a further upheaval, an interval of time measured by the more recent formations, nearly thirteen miles thick altogether, which are met with in succession as we cross England in an easterly direction, and the inconceivably slow process by which the whole surface of the country has been moulded into its present aspect, under atmospheric influences.

Let us now turn our attention, though it must be more briefly than the subject deserves, to the objects of antiquity which abound in this district. They are, for the most part, closely connected with the working of the lead mines, which in very early ages attracted to them the industry of the Romans.

Ingot of Lead from Linley.

An interesting testimony to this fact is extant in a large ingot of lead which is in the possession of Rev. F. More, of Linley Hall, and of which a sketch is here presented. This ingot is stamped with the words I. M. P. HADRIANI AUG., executed in well cut letters; its weight is just 190 lbs., and it is the exact duplicate, I am informed, of another that was discovered in a different place, but in the same neighbourhood. On each side it is possible to trace the grain of oak wood, stamped, as it were, upon the lead, from which it is inferred that the mould in which it was cast was made of that timber; but a more curious and interesting fact is the occurrence likewise on each side of the impression of a fern leaf, so distinct, that the species, *Blechnum boreale*, can be determined. How did this come here? Could that frail organism have permanence enough to impress its form on the molten mass as it was poured into the mould? Why one fern leaf on each side? Was it accidental or intentional, a kind of trade mark or private stamp? Together with this relic of Roman industry, Mr. More, whose diligence in collecting and preserving these curious remains

has been very great, has in his collection some ancient wooden spades of oak, and of a curious pattern. The handle was evidently inserted in the hole which is represented in the accompanying drawing, and tied to the short handle with which each was furnished; thus affording a tolerably effective implement when iron was yet an expensive metal. But lastly, Mr. More possessest wo precious relics, which, as being composed of far more perishable material, are justly prized by him very much; they are two candles, apparently formed originally of tallow, but this has undergone the change into adipocere, which frequently takes place with fatty substances when exposed for a very long time to certain atmospheric action, and by which it has become extremely hard and almost chalky in its nature. The form,



Spade found in Roman mine near Shelve.

Roman (?) Candle found in Roman mine near Shelve.

however, of these candles is quite preserved; they resemble our ordinary "dips," and a fracture in the side of one of them reveals an inner core, which would arise from their being formed by two successive dippings in the melted tallow. The wicks of both of them are made of hemp, cotton being then, of course, unknown. Both these and the spades were found in one of the workings of the Roman mine; and it is therefore possible that they date as far back as the times of that people. But although, as Mr. Wright informs me, there is good evidence that the Romans used candles, a candlestick having actually been found at Wroxeter, it might not be easy to determine that these interesting relics are of so ancient a date as this, since, indeed, the mines from which they came seem to have been in constant work down to the present day, when "Limited Liability" projects, to enrich the fortunate shareholders, teem on every hand.

In his antiquities of Shropshire, Mr. Eyton says of Shelve, that "it was famous in the twelfth and thirteenth century for its lead mines. In 1182, the king seems to have had the lead mines in his own hands. The sheriff had conveyed the king's lead from Shrewsbury to Gloucester, at the cost of £3 8*s.* 9*d.*, as certified by William Fitz Simeon and Warin Fitz Alric. He had further purchased 110 cart loads of lead for the king, at the cost of £38 10*s.* This lead is expressed to be 'ad operationes ecclesie de Ambresb.' This explains the whole

matter. The great Wiltshire nunnery of Aymesbury had been dissolved by Henry II. in 1177, on account of the immorality of its members. The house was newly inaugurated as an abbey on May 31 in the same year, and colonized with a purer sisterhood from the Abbey of Fontevrault. The King, the Archbishop of Canterbury, and the Bishops of Exeter and Norwich attended the ceremony. Henry II. left nothing undone which could contribute to the dignity of the new foundation, and Aymesbury became the select retreat for females of the aristocracy. The lead mines of Shelve doubtless furnished the roof of the conventual Church."

But it is time to draw our ramble to a close, although we have by no means exhausted the objects of interest in this neighbourhood, though we might with pleasure examine the curious circles of stones near the foot of Corndon, and the tumuli of departed heroes which are said to abound on its summit, and the relics of more recent times in the hypocaust and remains of a Roman villa which still exist close to Linley Hall; and though by permission of the hospitable owner of that handsome place we could with profit linger over the ingenious and most instructive model which he has had made of the surrounding country, enough will have been said to show that a few days spent in the neighbourhood of the Stiperstones will not be thrown away; and now that an excellent hotel (I am not a shareholder) is established at Church Stretton, a good centre of operations has been created, and a country for the most part inaccessible, if not inhospitable, has been opened up to the lovers of science and of scenery. It may be hoped that its many objects of interest may be investigated as they deserve to be.

PICTURE-NOTES.—THE ROYAL ACADEMY.

The picture exhibition of the Royal Academy for the present year is, on the whole, an interesting one; and it would be easy to make a pretty long list of artists whose works evince considerable technical skill, and possess a fair amount of beauty in colour or form. If, however, we pass by those pictures which are simply pleasing, and take no account of many preposterous and crotchety failures, we have left a good many productions of artists whose labours command large prices, whose reputation stands high, and who aim, more or less successfully, at an elevated mark. Amongst these there are some who deserve great praise, while others—and they comprehend several of the R.A.'s—have fallen far below their own fame. The deplorable want of English artists is mental cultivation and imaginative power. They rarely conceive their subjects in a fine spirit, and, as a rule, their pictures lack sentiment, dramatic vigour, and poetic treatment. The present exhibition shows these defects very glaringly, and chief amongst the defaulters are painters whose reputation has long been made.

Sir Edwin Landseer sins most grievously against all rational principles of art in his big picture of the "Queen at Osborne in 1866." The sentiment intended to be conveyed by this piece is that of the grief and loneliness of our sovereign in her widowhood. The queen is represented in a black riding-habit, on a dark pony, held by a gilly who looks as if he had been borrowed from the undertaker. A little dog, standing on his hind legs, seems, from the colour of his coat, as if he had put on mourning during a temporary sojourn up the kitchen chimney; the grass has the aspect of faded green baize, and a grey, drizzling cloud gives a damp, half-mouldy aspect to the scene. In his better moods Sir E. Landseer could not have painted such a picture. It is not a grief as conceived by the artist, but as it might be arranged for exhibition by the undertaker. The gentlemen who "perform" funerals could also "perform" this sort of woe, and hundreds of their profession would thankfully supply the article by contract, according to weight or measure, as might be agreed. A true artist—Sir Edwin himself in his artistic moods—would have perceived the morbid affectation and unnaturalness of the method of treatment which he has adopted, and which is founded on the conceit, that an air of general discomfort pervaded the universe because an illustrious personage died. There is however no symptom of that power which might command the sympathies of external

nature, fill the world with gloom, and "let darkness be the burier of the dead." A grand method of treatment, embodying this sort of conception, would, no doubt, have been out of place; it could only be appropriate to such a scene as that of Calvary, or some other stupendous tragedy, in which one of earth's noblest martyrs died.

As a rule, nature and life are full of contrasts; the grass does not wither, nor the puppy turn soot-colour, because death exacts his tribute from the domestic circle. Deep private sorrow casts no shadow on the skies or the fields; the flowers spring up in their glittering brightness, the lark soars and sings in the blue heaven, when the kindest hearts are withered, and the best beloved persons seek their resting-place in the grave. Landseer has failed, egregiously failed, in his delineation; the picture is weak, washy, maudlin, and unnatural. It suggests sore throats and lumbago, rather than the spiritual elements of bereavement and sorrow. Such a painting is unworthy of his genius. It is a dead thing, for which burial and forgetfulness would be the fittest award.

Mr. E. M. Ward, R.A., has tried his hand at a Shakespearian scene. "Juliet"—*his* Juliet, not Shakespeare's, is in Friar Lawrence's cell, receiving the "distilled liquor," which is to cause "a cold and drowsy humour" to "run through all her veins," so that "no pulse"

> "Shall keep his native progress, but surcease."

Juliet is a difficult character for any artist, histrionic or pictorial, to pourtray. To satisfy the requirements of the story, we must see her not only "rich in beauty," but in that rare and particular kind of beauty which expresses her character. Passionate, impulsive, timid, yet brave; desperate in loving, yet full of maiden modesty and grace. Romeo beholds her full of "Dian's wit,"

> "And, in strong proof of chastity well armed,
> She will not stay the siege of loving terms,
> Nor bide the encounter of assailing eyes,
> Nor ope her lap to saint-seducing gold."

Her passion for Romeo soars above and beyond the sphere of physical attractions. She idealizes his mind as well as his person. After Tybalt's death, when her nurse upbraids her, and exclaims, "Shame come to Romeo," Juliet retorts—

> "He was not born to shame:
> "Upon his brow shame is ashamed to sit,
> For 'tis a throne where honour may be crowned,
> Sole monarch of the universal earth."

Let any visitor to the exhibition keep this delineation in his mind, when looking at Mr. Ward's Juliet, and he will find in

his podgy, wooden-faced girl not a single lineament by which Shakespeare's Juliet should be recognized at a glance. The real Juliet seeks the aid of the Friar to save her from the marriage to which her family condemn her, at any risk. Love has made her bold. She will be "chained with roaring bears;" will be

> "Shut in a charnel-house,
> O'er-covered quite with dead men's rattling bones."

She will do the direst thing

> "Without fear or doubt,
> "To live an unstained life to her sweet love."

Not one glimpse or glimmer of such a Juliet is to be seen on Mr. Ward's canvass. He depicts an affrighted female who might be a provoker of melancholy, but would be a most decided antidote to love.

Mr. D. Maclise, R.A., is another artist who has maltreated Shakespeare in this exhibition. He has chosen a scene with Othello, Desdemona, and Emilia.

> "*Des.* Why is your speech so faint? Are you not well?
> "*Oth.* I have a pain upon my forehead here."

Just before this scene Iago has succeeded with his vile slanders in raising the jealousy of Othello, and his "pain upon the forehead" is the symptom of his mingled rage and grief. Desdemona binds his brow with the handkerchief he had presented to her. He lets it drop, and Emilia steals it, as her husband Iago had requested. This scene might, one should fancy, inspire an artist to pourtray the deep, half-raging, half-doubting passion of Othello, the tender fear of Desdemona, and the vulgar deceit of Emilia. There is some expression in Desdemona's face as depicted by Mr. Maclise—none in Othello's half-hidden countenance that is appropriate to the man or the occasion. The noble Moor might be dark, "black," as he calls himself, but he was a chivalrous gentleman, full of fine feeling, and poetic fancy. In all his chief speeches there is a blending of tenderness and imagination with the rougher nature of the warrior accustomed to "feats of broil and battle;" but none of these qualities are visible in the Othello of Mr. Maclise. He might be a street porter with some commonplace and vulgar grief, certainly not Shakespeare's Othello, whose unaffected narrative of "moving incidents by field and flood," made the high-born Venetian lady "love him for the dangers he had passed."

This picture is not only deplorably wanting in true conception of the characters, but its composition is unpleasing. The figures are uncomfortably huddled together, and an em-

broidered surcoat of Othello is more conspicuous than its wearer or his wife.

A third, and more recent R.A., very clever in the technicalities of his art, full of talent, destitute of genius, and therefore able without compunction to paint down to the taste of the vulgar rich, has chosen for his theme "King Charles the Second's Last Sunday," a picture for which a perfectly ridiculous price is reported to have been promised or paid. John Evelyn in his *Diary* speaks of "the inexpressible luxury, profaneness, gaming, and all dissoluteness" which characterized the last Sunday of Charles the Second's disreputable life. Towards the close of his reign England was profoundly disgraced by the policy as well as by the personal conduct of the wearer of the crown. Little better than a satrap of Louis XIV., looking to his aid in reducing this country to a despotism, usually neglecting public business, and passing his time in a round of debauchery and licentiousness, the king, as his end approached, was often a prey to melancholy, and possibly of remorse. Surrounded with gamblers and harlots, with a broken down constitution, satiated with vicious indulgence, without a real friend, an honest thought, or an inspiring hope, the last days of the Second Charles were passed in a degradation that no glitter of wine cups could illumine, no court splendours could dignify, and his "last Sunday" on earth, as described by Evelyn, was a scene of vanity and wickedness on which the preacher might dilate. All vile passions and low desires were represented at Whitehall on that occasion. Woman was there in a moral abasement, made all the more conspicuous by the mingled costliness and indecency of her costume; man figured as a beast, led by the two attendant demons, Licentiousness and Profanity. Revelry stifled conscience, lust smothered reason, —the devil seemed triumphant, but the avenger was nigh. Death was at work on the disreputable hero of the disgraceful scene, his seal was on his victim, and in six days the guilty monarch had to render his account of deeds done in the body—nearly all of shame.

A great artist is a great thinker, and such an one could only have selected such a theme for the purpose of contemplating it from a moral and ideal point of view. Why paint twenty dead and forgotten courtiers round gambling tables that have long mouldered into dust, except to show the stormy passions that attend such a career—recklessness, greed of unhallowed gain, violent disappointment, bitter remorse, and grim despair. These are the feelings which a great artist would bring before us in all their force and horror, if he obtruded a party of gamesters on our view; and if he depicted harlots at their revels, and a monarch sullying his crown in

their company, could he by possibility forget the bitter fruits that vice produces, the dramatic contrasts between the phantasmal pleasures of licentiousness, and the grim, stern realities to which they lead? Mr. Frith has painting power and drawing power, colour perception to a moderate extent; but thinking, reflecting, and idealizing faculties in very feeble force. His conception of the last Sunday of Charles the Second is vulgar and commonplace. Hampton Court supplied the portraits and the costumes; his own skill has grouped the various figures pretty well together, but the picture has no soul in it. His gamblers have no variety of expression; his Charles the Second looks hearty and well contented, as if lust had agreed with him, and promised length of days; his loose women are all flourishing, the revel successful, with nowhere an intimation of the fallacious character of mere animal enjoyment. He may reply that good for nothing people do often make themselves very comfortable, and we grant the fact; but a great artist would not paint them simply to show that fact. The only justification for a true artist dealing with such subjects is his capacity for seeing further and deeper into character, conduct, and its results, than ordinary mortals can realize without aid. Mr. Frith has in his mind evidently nothing more than the rudest externalities and upholsteries of such a scene, and so his picture, technically clever, is æsthetically good for naught.

By introducing John Evelyn surveying the scene with a wobegone, methodistical countenance, Mr. Frith may suppose he has made his canvass "point a moral;" but Nature does not inculcate her lessons in this commonplace way. What a looker-on thinks of vice is of less consequence than what vice is, and whither it leads; and the collection of reprobates at Whitehall must, in their own persons, have made the ignominious failure of their lives, and the certainty of retribution, more conspicious and repulsive than could be effected by any comments a bystander might make.

It seems as if putting Shakespeare in purgatory were a special function, to the discharge of which R. A.'s committed themselves last year. We have had a Juliet scandalized, an Othello travestied, and we have only to go a little further to find a Jessica traduced. Mr. C. W. Cope, R.A., is the offender in this case. Shylock is giving her his keys, and the Jew and his daughter are the only figures introduced. Whether Mr. C. W. Cope, R.A., ever read the *Merchant of Venice*, we cannot venture to guess. We hope not, because, if he took his Jessica from some bad, second-hand imitation, there may still be some hope for him on his first introduction to the young lady herself; but, if he did read the play, his case must

be desperate indeed. Every Shakespearian reader recollects with delight the exquisite scene in the avenue to Portia's house, where Lorenzo and Jessica enjoy their pretty talk under the bright moon, and Jessica shows wit, culture, and fancy deliciously combined. Mr. C. W. Cope, R.A., has bestowed none of these qualities upon his Jessica, who looks rude as a milkmaid, is dressed in vile taste, and has a chignon behind! It would be the most useless thing in the world to tell such a Jessica that

> "The floor of heaven
> Is thick inlaid with patines of bright gold;"

or to expect her to respond to the statement—

> "There's not the smallest orb which thou behold'st,
> But in his motion like an angel sings,
> Still quiring to the young-eyed cherubins."

The earthy solidity of Mr. Cope's Jessica is proof against such fancies; she has the countenance of a fish girl, and in reply to her lover's poetry might tell him the price of sprats.

The colouring of this picture is ugly, as is its failure in sentiment. Shylock's snuff-coloured gaberdine is not pleasant to look at, and Jessica's dressmakery would put Houndsditch to shame. She is trimmed out in a blue speckly sort of gown, touched up with yellows and reds, and the whole effect is harsh and displeasing.

Another R.A., Mr. S. A. Hart, has sinned against the harmonies of colour in a big picture, representing the submission of Barbarossa to Pope Alexander the Third. The succession of incongruous reds in great patches, including the sprawling emperor, are very disagreeable, and the corpse-coloured pope makes the matter worse. Such a piece may, however, be useful to young colourists, as showing them exactly what they ought not to do. We hope it will operate effectually, and pass it by.

We intended to have said something about the "Hookscapes"—all clever, all mannerized, and all alike in the same sort of red-faced boys, opaque green seas, and impossible cliffs and shores. The best and the worst is called "Mother Cary's Chickens," and will be a favourite with many, though the sea lacks the transparency of water, and the waves are nearly destitute of those innumerable cross lines and curved surfaces in various glittering planes which real waves always present; but we are sick of grumbling, and must look to something we can praise.

Taking the good pieces in the order of the catalogue, we must pay our first tribute to the fine drawing and remarkably

beautiful colouring of Mr. Goodall's "Rebekah," though as a whole, the picture has little hold over our sympathies. Passing by several pieces more or less worthy of note, we reach "The Highland Lass Reading," by the late J. Phillip, painted with that happy mixture of truth and freedom of which he was so great a master. The simplicity and earnestness of the girl's face are charming. A common artist would have made the "Highland Girl" a fine lady; Phillip has thrown over her a rich glow of idealism, without departing from truth. Cooke has given a fine view of "the Canal of the Giudica, in Venice;" and Lee a beautifully painted "Scene on the Road from Funchal, in Madeira," in which the colour of foliage and the effects of light are singularly graceful and true.

The "Jephthah," by Millais, is one of those pictures which, whatever minor faults it may possess, realizes a high conception of the scene, and excites our sympathies by its dramatic power. The chieftain has returned, his daughter has met him, and in deep agony of soul, he exclaims, "Alas! my daughter, thou hast brought me very low, and thou art one of them that trouble me, for I have opened my mouth unto the Lord, and I cannot go back." The revulsion from the triumphs of victory to the heart-broken perception of the fearful cost at which they have been won, is grandly told. Jephthah, anguish-torn in mind, prostrate in body, is presented as an object of even greater pity than his daughter—we feel that he is a victim more wretched than the maid. The attitude of the various figures, and the expression of their countenances, tell the story admirably; and whatever we may think of Mr. Millais' failings, this, like many other of his productions, is full of that genius which places him in the foremost rank.

Next in catalogue order is a widely different class of work; but it is so remarkable for its luxuriant brilliance of colouring that it cannot be passed by—we mean Miss Murtrie's beautiful flower piece, "Margaret's Corner," a very gem in its way, though an awkward companion for pictures painted in a lower key.

"Home after Victory," by S. H. Calderon, has fine qualities, but it is too "stagey." A knight in armour returns to his castle; his father stands with outspread arms to receive him, and his mother and wife have rushed forward, and are clinging to his arms. The face of the knight is not up to the mark in point of expression. He does not come near Wordsworth's "Happy Warrior," but the piece as a whole is good, and it is evident that Mr. Calderon thinks out his subjects before putting them on his canvas.

Mr. Faed has a piece of his usual merit. "Old Life" is a good specimen, but it is too prosy to take first rank. Mr.

Marks is remarkably clever, though verging too much on caricature in "Falstaff's Ragged Regiment;" and Mr. Stone has given a pleasing picture of Nell Gwynne, in the days of her orange-girlhood, giving fruit to an old soldier.

We now come to the most beautifully painted picture in the exhibition—the "Rachel" of Mr. F. Goodall, remarkable for its finished, accurate drawing, and for its mastery over difficulties of colour. "Rachel"—we do not know that we identify her particularly with the Bible character—is descending the steps of a well with a pitcher on her shoulder. The light glows on her rich brown complexion, falls softly on her amber-toned drapery, and gives a singular beauty to her finely-moulded arm. The perfect roundness of the limbs, the swelling of the muscles, and the strikingly natural way in which, while they stand out against the sky, their edges soften into it, are great triumphs of technical art. The colours are peculiar, and remarkable for that delicate combination of richness and softness which have characterized Mr. Goodall's productions since his Egyptian tour. The sky has a greenish-blue tint; the girl is partly enveloped in a soft yellowish-tinted robe, sparingly relieved by a narrow red girdle, and a blue and red stripe in the border. The sunlight falls with a mellow richness seldom equalled; it absolutely glows on the dress, and the soft transparent shadows seem to move as the spectator gazes upon them. Very rarely has an English artist produced so exquisite a work, and we are glad to learn that it has realized a price seldom given for a single figure. We should like to see Mr. Goodall in a more dramatic style. He calls this figure "Rachel," but many other names would do as well. It is evidently true to nature; but it is not specially true of any particular personage in story or song.

No visitor to the exhibition can fail to notice Mr. Carter's sheep skurrying away from a wolf, and starting out of the frame, as if in full tear towards the spectator, and ready to plump down from their place over the door of the west room. This picture is a clever specimen of this particular perspective, and the animals are full of vigour and expression.

Mr. J. T. Linnell has a fine picture, called the "Mountain Road," but, as usual, mannerised, and we miss amongst the landscape-artists any one who has successfully entered on a new path. Of graceful pieces, like Lee's "Salmon Poachers Discovered," several might be named; but a grand and natural style of landscape art seems not at present to exist amongst the various candidates for fame. Mr. Vicat Cole has, however, made a handsome departure from the conventional methods of marine painting, and the play of light on the yesty sea depicted in No. 489 is very fine. This sea has evidently

been studied in the right way. Mr. Cole has looked at nature, while very clever Mr. Hook finds his seas in his "inner consciousness," just as the German philosopher constructed his camel out of the same material, without prejudicing his mind by attention to the reality. It is astonishing how many artists, and even clever ones, seem incapable of seeing the variety of nature. They hit upon a conventional mode of depicting rocks, trees, men, and women, as the case may be, and it never occurs to them that no lofty function of art can be performed by the endless repetition of the same idea. The ablest of this school of error are the Linnells and Mr. Hook. Their talent makes them mischievous, for though few attempts may be made to imitate their particular and objectionable mannerisms, they make the vice of mannerism more respectable than it would otherwise seem.

GRAPTOLITES: THEIR STRUCTURE AND SYSTEMATIC POSITION.—PART II.

BY WILLIAM CARRUTHERS, F.L.S.

(*With a Plate.*)

Classification. The generic name *Graptolithus* was established by Linnæus, as we have seen, for a heterogeneous group of objects, among which a single form of the fossils to which the name is now referred, was placed by him only in the last edition of the *Systema Naturæ*, which had his editorial superintendence. The difficulty of confining this designation to one of the various items included in the genus, and especially of applying a word to these organic remains, which its author employed to indicate that the species included under it were imitations of and not real fossils, presented itself to those who after Linnæus studied this family. Nilsson proposed the name *Priodon* for the true graptolites, but as this word had already been given by Cuvier to a genus of fish it was withdrawn, or, rather, slightly altered into *Prionotus*. This new form of the word was first published by Hisinger, in his descriptions of the fossils of Sweden, in 1837. Before this, however, Brown (1835), had published the name *Lomatoceras*, but with a strange fatality he fell into the same error as Nilsson, having overlooked that this name had already been employed for a genus of insects. The original name was restored by Murchison in his *Silurian System* (1839), in a slightly altered form (*Graptolites*), a spelling which has been universally followed by British authors. In the same work, however, Dr. Beck's note

on the family is introduced, and he retains the word according to the original Linnæan spelling, in which he is followed by writers abroad. Under this name all the numerous and varied forms were included which had been described by Hisinger, Murchison, Portlock, Hall, Geinitz, and others.

Barrande, in his valuable memoir on the graptolites of Bohemia (1850), first subdivided the genus. He established the new genera—*Rastrites*, for species with the cells separated by distinct interspaces on a slender axis (Plate I., Fig. 17; Plate II., Figs. 9 and 10), and *Retiolites* for a somewhat anomalous form without a central solid axis (Plate I., Fig. 12). He further divided the restricted genus *Graptolithus* into two sections, the one *Monoprion*, characterized by possessing a single series of cells (Plate II., Figs. 1, 3, 7, etc.), and the other *Diprion*, having a double series of cells (Plate II., Figs. 2, 4, 5). M'Coy in the same year gave these sections a generic value, retaining the original name for Barrande's *Monoprion* group, and proposing the name *Diplograpsus* for the species included in the section *Diprion*.

Barrande, accepting Hisinger's determination, considered the *Priodon sagittarius* of that author the same as *Graptolithus sagittarius*, Linn., and consequently held the species with a single series of cells to be the true Linnæan type of the original genus. He further endeavoured to show that *G. scalaris*, Linn., was a "scalariform" impression of a single-celled species, and by an oversight which is remarkable in a work specially characterized by the careful and accurate observation that distinguishes all the labours of its illustrious author, he figures a double-celled graptolite as the "scalariform" impression of two single-celled species, viz.: *G. nuntius*, Barr., and *G. Halli*, Barr., as has been already pointed out by Hall. M'Coy, influenced by similar considerations, erroneously retained the Linnæan generic designation for the single-celled forms. Were it not that he has been invariably followed, I would venture to restore the name given by Linnæus to the only form with which he was acquainted; but this would introduce into the accepted nomenclature so many changes without corresponding advantages, that the strict application here of the law of priority would scarcely be justified.

Suess, in 1851, added the synonym *Petalolithus* to M'Coy's genus *Diplograpsus*.

In the same year M'Coy further separated a well-marked group of species, in which the polypary consists of two simple branches, from his restricted genus *Graptolites*, for which he proposed the name *Didymograpsus* (Plate II., Fig. 12), and in the following year Geinitz applied the title *Cladograpsus* to the same. Unaware that this name had been employed, I pro-

posed it in 1858 for a repeatedly branching form, which I detected in the shales of the south of Scotland. While the paper in which I described this and other forms was passing through the press, I learned that Geinitz had used the name, but as I was unable to ascertain to what group he applied it, I permitted the name to stand. In the same paper I described a new species of *Didymograpsus*. As I applied the name obviously to a different group, it must, following the ordinary rule in such cases, be retained for the forms to which I applied it. This is a slender graptolite, looking like a pencil line drawn in beautiful curves, or in nearly straight lines on the surface of the laminæ of the shale in which it is preserved. The numerous branches are arranged sub-symmetrically on the two sides of the primary point.

Salter, in 1861, described a compound form from the Skiddaw slates, similar to some that had already been observed in Canada by Sir William Logan, to which he gave the name of *Dichograpsus*. The fragments of this genus cannot be distinguished from imperfect specimens of the limited genus *Graptolithus*, but the discovery of the beautiful examples found in Canada, and even of the less perfect ones obtained from Cumberland, show that the complete organism was somewhat complex. They were developed symmetrically from a primary point, which Hall calls the "radicle," and dividing more or less frequently in a dichotomous manner, they terminated in greatly, apparently indefinitely, produced, simple, one-celled branches. The slender bases of the branches at the centre of the organism was supported by a flat, corneous disc.

Hall, in 1857, established the genus *Phyllograptus* for a remarkable form consisting of four series of cells, united to each other by their longitudinal axes. In subsequently published papers he proposed several additional genera for organisms found in the Quebec rocks, some of which most probably belong to other families than the graptolites. In some he can detect no cell openings, and *Inocaulis*, which is not rare in our British Silurians, has a solid homogeneous structure very different from that of any graptolite. One of his new genera is represented in Britain by two species, *Dendrograptus*, a remarkable form in which a common stem to the polypary is produced, apparently as in the recent *Halecium*, by the aggregation of numerous tubes, which are the non-polypiferous basal extremities of the branches. He has also established two new genera for organisms that had found places in already established genera. In *Diplograpsus* the polypites were contained in distinct hydrothecæ (Plate II., Fig. 5); but in a few species the cells bearing the polypites were excavated in the margin of the common polypary (Plate II., Fig. 6), and for those

having a structure so very different, he proposed the name *Climacograptus*. The Linnæan *Graptolithus scalaris* belongs to this restricted genus, and Hall, who was aware of this, recognized the original specific designation in proposing the new name. He is not, however, aware that he is here dealing with the only species which Linnæus knew, but, like all other writers, he erroneously considers Hisinger's *Priodon sagittarius* to be the Linnæan type of the family.

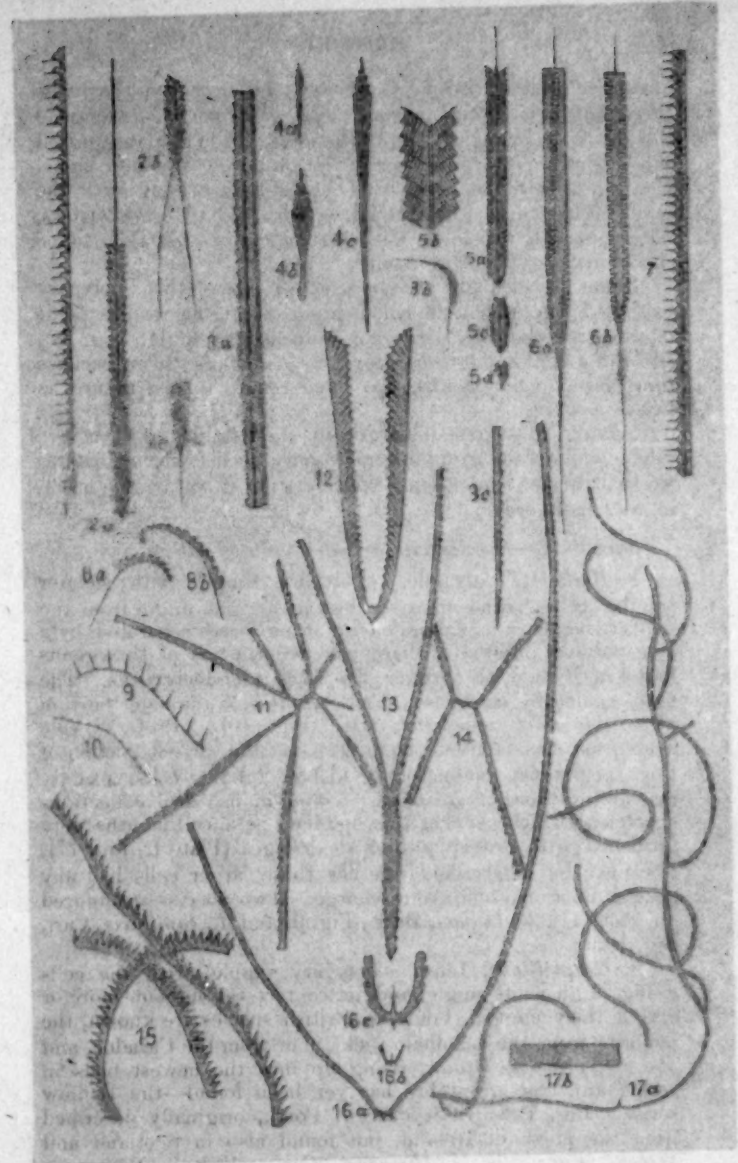
Some species of *Didymograpsus* have this polypary extended into a double-celled prolongation below the point of union of the two diverging branches (Plate II., Fig. 13), and these Hall names *Dicranograptus*, chiefly, however, because they have, as he thinks, the same remarkable structure as *Climacograptus*.

Having thus traced historically the establishment of the different genera of graptolites that have been found in Britain, we shall better understand their relation if we arrange them in systematic order.

SECTION I.—*Species with a single series of cells.*

1. *Rastrites*, Barrande. Polypary simple, with slender tubular cells, rising more or less at a right angle from the delicate capillary axis, and having their bases separated by a considerable interval. There are five species of this genus found in Britain, all of them from the Llandeilo rocks. The fossil named by Harkness, *R. triangulatus*, is the older portion of *Graptolithus convolutus*, His. (Fig. 15). Prof. Wyville Thompson has pointed out to me that the earliest portion of this species was composed of distant tubular cells, exactly resembling those of *Rastrites*. I find in my own collections specimens which confirm this opinion. The cell mouths were furnished with two spine-like appendages (Plate I., Fig. 17). It cannot be determined whether these larger cells had any special functional office to discharge. Two species are figured on Plate II., *R. Linnæi*, Barr., Fig. 9, and *R. capillaris*, Car., Fig. 10.

2. *Graptolithus*, Linn. Polypary simple, with the cells rising at an acute angle, and in contact throughout more or less of their length. Fourteen British species are known, the majority from the Llandeilo rocks, four from the Caradoc, and one, *G. priodon*, Bronn, rising up into the newest beds in which any true graptolite has yet been found—the Ludlow series. Fig. 1 is *G. Sedgwickii*, Portl., originally described from the north of Ireland, but found also in Scotland and Wales. Fig. 3 is *G. Hisingeri*, Car., which is Hisinger's *Priodon sagittarius*. To prevent further confusion, as well as to correct an error, I have set aside the false Linnæan specific



BRITISH GRAPTOLITES

name, and I gladly find another in the name of the original describer of the species. Fig. 3, *c* is the proximal end of the polypary. Fig. 7, *G. Halli*, Barr. Fig. 8, *a* and *b* are two perfect specimens of a beautiful small species, which at first I referred to *G. millepeda*, M'Coy, but that species is certainly the proximal end of *G. Becki*, and this differs from it in having a very broad common base, from which the hydrothecæ rise. I have dedicated this species to my late friend, J. Morison Clingan, M.A., who was my frequent companion in rambles among the Moffat Hills. *G. Clingani* could not have been part of a compound organism, as Hall supposes, but is evidently complete in itself. Fig. 3, *b* represents a specimen of another species, in which both extremities are perfect; and, though I have never seen large specimens showing both extremities, yet fragments of the ends are not unfrequent, and these conclusively show that the complete organism corresponded in structure with the small and more frequently perfect *G. Clingani*. *G. convolutus*, His., is represented at Fig. 15.

3. *Cyrtograpsus*, Car. Polypary compound; growing in one direction from the primary point. One species only is known from the Wenlock rocks.

4. *Didymograpsus*, M'Coy. Polypary compound; growing bilaterally, and consisting of two simple or double branches. In this genus I include Salter's *Tetragrapsus*, some species of which would, perhaps, better be joined to *Dichograpsus*. Eleven species of this have been observed, all from the Llandeilo beds, except one, which is found in the Caradoc series. Fig. 12 is *D. Murchisonii*, Beck. sp.; Fig. 14, *D. crucialis*, Salt. sp.; and Fig. 16 is an undescribed species from the Moffat shales, for which I propose the name *D. elegans*. A young specimen is figured at 16, *b*, and *c*, showing the "radicle," which subsequently disappears, and the three processes on the convex side, which are always present in this, as in some other species of the genus.

5. *Dichograpsus*, Salt. Polypary compound; growing bilaterally, and branching regularly; the non-celluliferous bases of the branches invested with a corneous disc. Several species of this genus have been found in Canada, but hitherto only two have been detected in the Llandeilo beds of this country, of which *D. aranea*, Salt., Fig. 11, is one.

6. *Clodograpsus*, Car. Polypary compound; growing bilaterally from the primary point, irregularly, and repeatedly branching and rebranching, and without a central disc. Two species of this genus occur in Britain, both in the Llandeilo beds, one of which, *C. lincaris*, Car., is figured Fig. 17. It is a very slender species, and the drawing represents it as somewhat too broad.

7. *Dendrograptus*, Hall. Polypary compound, with a thick common stem, giving off branches irregularly, which repeatedly sub-divide in a dichotomous manner. Two species have been noticed in Britain, one from the Llandeilo and the other from the Caradoc beds. Both species are founded on fragments of the polypiferous branches, but these agree so exactly with the species described by Hall, that there can be little doubt as to the genus in which they should be placed.

Section II.—*Species with two series of cells.*

8. *Diplograpsus*, M'Coy. Polypary having a slender, solid axis, and with cells composed of true hydrothecæ. Nine species are known, and all of them from the Llandeilo beds. Fig. 2 represents one of the best known species, *D. pristis*, His. sp. The proximal end is furnished with three spines, all of which have the same origin; the two lateral ones are not the ornaments of individual hydrothecæ, but have the same relation to the general polypary as the terminal one. Different forms of these spines are figured at 2, *a*, *b*, and *c*. Fig. 5 is *D. folium*, His., which is destitute of any ornament at the proximal end. The individual hydrothecæ are marked by parallel ridges, as if they increased in size, shown in the enlarged portion at Fig. 5, *b*. Small specimens are figured at 5, *c*, and *d*. Fig. 4 represents an anomalous form, *D. cometa*, Gein., having a very small number of cells (3 or 4) on either side of the main axis, and these cells are very much produced, so as to appear almost parallel to the solid axis.

9. *Climacograptus*, Hall. Polypary, having a slender solid axis, and with the cells hollowed out of the body of the polypary. Three species are known in Britain, one from the Llandeilo beds, another from the Caradoc, and the third common to both series. Fig. 6 is *C. scalaris*, Linn. sp., a species which has been rejected by some authors as only a state in which almost any species might occur, and has been by others so misunderstood, that it has appeared under no less than ten different specific names. The relation between specimens preserved so as to show the cell mouths in profile (Fig. 6, *b*), and those exhibiting them in a front view, as transverse or "scalariform" markings on the upper surface, is beautifully shown in a specimen figured (6, *a*), in which the polypary is so twisted as to show the one set of markings on its upper half, and the other on its lower half. I have noticed that the prolonged axis of this species at the proximal end is frequently invested for a short distance by a sheath (Fig. 6, *b*).

10. *Retiolites*, Barr. Polypary without a solid axis, cells rising from a central common canal, and in contact throughout

their whole course; polypary reticulated on the outer surface. Two species of this singular genus have been found in the Wenlock beds of Britain (Plate I., Fig. 12).

SECTION III.—*Species with single and double series of cells on different parts of the same polypary.*

11. *Dicranograptus*, Hall. This is proposed by Hall as a subgenus of *Climacograptus;* but as the form of the polypary has been used by all authors as the principal basis for the separation of genera, this must be recognized as a good genus. A single species, *C. ramosus*, Hall, has only hitherto been described in Britain, and that is from the Llandeilo beds. It is figured (13).

SECTION IV.—*Species with four series of cells.*

12. *Phyllograptus*, Hall. Polypary consisting of four laminæ joined throughout their whole length to a common solid axis, and so giving four separate and independent sets of cells. A single species has been found in the Llandeilo rocks, but I have figured (Plate I., Fig. 5, *a*) an American species and (5, *b*) a transverse section, after Hall, which exhibits, better than the more imperfectly preserved British specimens, the structure of the genus.

Systematic position.—There is, perhaps, no small group of fossils concerning which so many and so different estimates as to their systematic position have been entertained. Linnæus, as we have seen, considered that the species which he knew was not a true fossil. Bromel, as early as 1727, is believed to refer to graptolites in his account of the fossils of Sweden, when he speaks of the fossil leaves of grasses; their vegetable origin has been maintained by several subsequent writers. Brongniart includes them among the Algæ, and figures two species in his great work, *Histoire des Végétaux Fossiles;* and in this opinion he was followed by several of the earlier American geologists, as Mather, Conrad, and Vanuxem.

As equally erroneous, the opinions of Boeck, M'Crady, and Nimmo may be at once set aside. Boeck considers them to have been hollow tubes, rent asunder in different ways before being buried in the mud in which they are preserved. They were probably, he thinks, the arms of radiata or cephalopoda, and the various forms described as different species are the result of the accidental tearing, and the irregular contraction of the substance of the tube. M'Crady considers that the graptolites are the larvæ of echinoderms, because of their similarity in form to Müller's published drawings. Nimmo thinks they are nothing more or less than the serrated spines of the *Raja pastinaca*, or an allied species. It does not appear

from Nimmo's notice that he had ever seen a graptolite, and his absurd conjectures may be excused, while the folly of its publication evidently rests with the then editor of the *Calcutta Journal*. M'Crady and Boeck, on the other hand, came to their conclusions after examining specimens; but the descriptions already given of the structure and general form of these fossils render it unnecessary to refute such notions.

Walch is the first naturalist who recognized the animal nature of graptolites. In his work on the fossils of Knorr's Museum, he figures two species, which he describes as small toothed orthoceratites. The one is most probably *G. priodon*, preserved in the round, represented externally in one figure, and in section in the other. Geinitz has mistaken the dark-coloured divisions between the cells shown on the surface of the polished slab for specimens of *Rastrites peregrinus*. The other species figured is *G. convolutus*. Walch's opinion that they were minute cephalopods was entertained by many naturalists, among others by Wahlenberg and Schlotheim. Barrande at length set the matter at rest by clearly showing that they could not structurally belong to this group, but must be zoophytes.

Nilsson, the venerable Swedish naturalist, was the first to suggest their true affinities. Some thirty years ago he was engaged in the study of these fossils, and published an abstract in anticipation of a complete memoir, which he has never given to the world. At that time the classification of zoophytes was very imperfect, and in the family Ceratophyta, to which he referred them, were included a number of organisms now known to have no affinity with each other. Beck, in a note in Murchison's *Silurian System* (1839), refers them to the neighbourhood of *Pennatula*, and he has been followed by Barrande and others. The possession of a solid axis, and of a free polypary, are the points chiefly relied on by those who maintain this view. M'Coy thinks they were Sertularians, because the form of their horny polypary and the polype cells were the same as in that family. Salter, Greene, and others would raise them much higher in the scale by placing them amongst the *Polyzoa*.

In trying to estimate, if it be possible, which of these opinions is the most accurate, it will be necessary to ask first, what are the characters to which we have access in graptolites that are most important in throwing light on their systematic position. Some make the general form of importance; but, on the one hand, this is one of the most variable characters in the same family, and on the other, it is one which repeats itself in very different families. It would be impossible to distinguish between the *Hydrozoa* and the *Polyzoa* from general

form. Besides, we find this very variable amongst the graptolites themselves. Nor is the fact that the polyparies were free of much significance, inasmuch as there are free forms among both the *Polyzoa* and *Hydrozoa*. The only trustworthy characters for the purpose we want are to be obtained, I believe, from the structure and relation of the individual parts of the polypary. In the *Polyzoa* there is a distinct septum cutting off the individual from the common canal, except by a comparatively small perforation. In the *Hydrozoa* the polype rises directly from the cœnosarc, and this also is the structure of the graptolite. This would, then, at once set aside the *Polyzoa*, and restrict the inquiry to the humbler cœlenterate zoophytes. The general resemblance between the free *Pennatula*, with its prolonged axis and bilateral arrangement of parts, and *Diplograpsus*, will not bear even a little scrutiny. The axis is slender and corneous, and is produced at the distal end of the organism, while in *Pennatula* it is thick and fleshy, and proceeds from the proximal end. The cells containing the animals are dug out of the cœnosarc, and strengthened with calcareous deposits in *Pennatula*, while in the graptolites the polypary is corneous and external, agreeing in this respect also with the *Hydrozoa*. There are, no doubt, some structures for which it is difficult to find anything corresponding among the *Hydrozoa;* but making every allowance for them, and considering the many and important points which they have in common, there is a strong case made out for the graptolites being *Hydrozoa*, although a somewhat abnormal form.

EXPLANATION OF PLATE II.

Fig. 1. *Graptolithus Sedgwickii*, Portl.

Fig. 3. *Graptolithus Hisingeri*, Car. *a*, portion of the adult polypary; *c*, proximal end, with small cells; *b*, young specimen of an allied species.

Fig. 7. *Graptolithus Halli*, Barr.

Fig. 8. Two perfect specimens of *Graptolithus Clingani*, Car.

Fig. 15. Fragments of *Graptolithus convolutus*, His.

Fig. 2. *Diplograpsus pristis*, His. sp. *a*, complete polypary; *b* and *c*, different forms of the proximal spines.

Fig. 4. *Diplograpsus cometa*, Gein. Three different forms.

Fig. 5. *Diplograpsus folium*, His. sp. *a*, complete polypary; *b*, portion magnified; *c* and *d*, young individuals.

Fig. 6. *Climacograptus scalaris*, Linn. sp.

Fig. 9. *Rastrites Linnæi*, Barr.

Fig. 10. *Rastrites capillaris*, Car.

Fig. 11. *Dictograpsus aranea*, Salt.

Fig. 12. *Didymograpsus Murchisonii*, Beck.

Fig. 14. *Didymograpsus crucialis*, Salt, sp.

Fig. 16. *Didymograpsus elegans*, Car. *a*, portion of an adult specimen; *b*, young specimen, showing the primary point, or "radicle;" *c*, the same magnified.

Fig. 17. *Cladograpsus linearis*, Car. *b*, portion magnified to show the form of the cells.

FLYING MACHINES.

In all ages men have envied the powers of flight possessed by birds, and from ancient to modern times inventors and schemers have busied their brains with devices intended to confer upon humanity the desirable faculty of aërial locomotion. For the most part, such efforts have been made by a class of projectors whose folly and infatuation have thrown ridicule upon the idea. Over and over again, the most absurd contrivances have been represented as sure to achieve success—a little more money was the only thing required; and if a sympathizing public would only find the funds, blundering enthusiasts promised, and believed, that they would fly like jackdaws from the neighbouring steeple, or soar like eagles far above the haunts of men.

The recent establishment of an "Aëronautical Society" in this country, under the presidency of the Duke of Argyll, and with a council containing such men as Sir Charles Bright and William Fairbairn, James Glaisher and F. H. Wenham, has already had the curious effect of raising expectations in scientific minds, that at last some form of flying apparatus may be made to succeed. Of late years, a partial study of the wings of birds, and of their methods of action, seemed to show that flight was a physical impossibility for man. The size of the bird's wing was so large, in proportion to the creature's weight, and it appeared to demand so great an amount of muscular force for its movements, that it seemed perfectly hopeless to expect that human muscles could wield an apparatus of the required dimensions, and with the velocities demanded, or that any mechanism could be constructed generating sufficient force in proportion to its weight. Mr. Wenham's researches into the matter have materially modified the opinions of those who heard his paper read, or who have perused it in the *First Annual Report of the Aëronautical Society of Great Britain*.*

He has thrown much light upon that very complicated and

* Published by Cassell and Co.

abstruse question, the flight of birds, and he has established good reasons for supposing that there has been much exaggeration in the popular estimate of the force exerted in the operation. We hope our readers will have recourse to the publication we have named; but, as an incentive to consult it, and for the benefit of those who are not likely to see it, we shall proceed to give a condensed account of its contents. Mr. Wenham tells us that a weight of 150 lbs. suspended from a surface of the same number of square feet, will fall through the air at the rate of 1300 feet per minute, the force expended on the air being nearly six-horse power. Consequently, that power would be required to keep the same weight and surface suspended at a fixed altitude. A man can perform muscular work equal to raising his own weight, say 150 lbs., twenty-two feet per minute; but at this low rate of speed he would require to sustain him on the air a surface of 120,000 square feet, making no allowance for weight beyond his body. Thus, attempts to construct bird-like wings, by which a man could raise himself perpendicularly, appear quite impracticable.

A pelican, shot by Mr. Wenham, on the Nile, was found to weigh 21 lbs., and its wings measured ten feet from end to end. During their flight, pelicans make about seventy wing strokes per minute, and when they float on the air, a few strokes in each minute appear sufficient to sustain them, and there is no symptom of powerful exertion. Mr. Wenham also noticed that flocks of spoonbills, flying at about thirty miles an hour, at less than fifteen inches above the Nile's surface, did not create a sufficient commotion in the air to ripple the surface of the water. Studying the behaviour of an eagle impelled to activity by a charge of large shot rattling amongst his feathers, he also noticed that he had to run at least twenty yards before he could raise himself from the earth. Many other observations of birds are highly important, and enable us to form some conception of the way in which various kinds of wings perform their work.

Citing Smeaton, Mr. Wenham informs us, that if a plane moves against the wind, or the wind against a plane, at the rate of twenty-two feet per second, 1320 feet per minute, or fifteen miles an hour, a force of one lb. per square foot is obtained. When a falling body, having a weight of one lb. to each foot of resisting surface, reaches that velocity, the atmospheric resistance balances its weight, and keeps it from descending faster. A man and a parachute, weighing together 143 lbs., will not fall with a greater velocity if the parachute is kept in position, and has an area of 143 square feet. A fall of eight feet brings a body to the earth with the same velocity, which is not sufficient to destroy life or

limb. Swallows have a wing surface of two square feet to the pound; some of the duck tribe, which fly well, little more than half a square foot, or 72 inches to the pound. If such birds allowed themselves to fall perpendicularly, with outstretched wings, they would reach the ground with an injurious velocity, but by descending obliquely, they alight with ease and safety. This combination of a horizontal motion with a perpendicular one is of the greatest importance; and Mr. Wenham observes, "In the case of *perpendicular* descent, as a parachute, the sustaining effect will be much the same, whatever the figure of the outline of the superficies may be, and a circle affords, perhaps, the best resistance of any. Take, for example, a circle of twenty square feet (as possessed by the pelican), loaded with as many pounds. This, as just stated, will limit the rate of perpendicular descent to 1320 feet per minute. But instead of a circle sixty-one inches in diameter, if the area is bounded by a parallelogram ten feet long by two broad, and whilst at perfect freedom to descend perpendicularly, let a force be applied exactly in a horizontal direction, so as to carry it edgeways, with the long side foremost, at a forward speed of thirty miles an hour—just double that of its passive descent—the rate of fall, under these conditions, will be decreased most remarkably, probably to less than one-fifteenth part, or eighty-eight feet per minute, or one mile per hour." This diminution of the descending velocity is occasioned by the resistance of the mass of air moved by the parachute in its horizontal course, and which necessarily becomes greater in proportion to the width of the parachute.

Among the experimental illustrations suggested by Mr. Wenham is the action of a thin blade, one inch wide and a foot long, fixed at right angles to a spindle on which it can be turned. If such an apparatus is immersed in a stream running in the direction of the spindle, and held at rest, the force which the blade has to resist will be simply that of the water current acting on its surface, and the current will be checked to a corresponding extent. If, however, the spindle and blade are made to rotate rapidly, "the retarding effect against direct motion will now be increased over *tenfold*, and is equal to that due to *the entire area of the circle of revolution*. By trying the effect of blades of various widths, it will be found that, for the purpose of effecting the maximum amount of resistance, the more rapidly the spindle revolves the narrower may be the blade."

It will be evident, that if a column of air were rotating in the same direction and with the same velocity as that of the vane and spindle, the movement of the vane would not be resisted by the air, and just to the extent to which the revolving

vane communicates its own motion to the air, the reaction of the air against the motion of the vane will be lessened. If at each moment of its progress in a horizontal direction the vane acted upon a stratum of air whose *vis inertiæ* had not been disturbed, the maximum of reaction would be obtained. Mr. Wenham, in a very ingenious way, applies these facts to the action of the long wings of swallows, and other birds characterized by the length of their flying apparatus, and he shows very pointedly the great mechanical disadvantage at which a bird or a machine must operate in order to raise a weight *perpendicularly*, as compared with raising it obliquely. He says it does not appear that any large bird can raise itself perpendicularly in a still atmosphere, but pigeons can accomplish it approximately to a moderate height, and the humming-bird, by the extremely rapid vibration of its pinions, can sustain itself for one minute in still air in the same position. "The muscular force required for this feat being much greater than for any other performance of flight. The wings uphold the weight, not by striking vertically downwards upon the air, but as inclined surfaces reciprocating horizontally like a screw, but wanting in its continuous rotation in one direction," and, therefore, with some loss of power from the rapid alternation of motion.

A bird is sustained in the air by the *weight* of that fluid, and the sustaining power of its wings will depend upon the quantity or weight of air that would have to be displaced by its fall. By a wide stretch of wing, and a horizonal motion, the resistance is maximized, and a long-winged bird that has raised itself in the air may avoid falling by maintaining a certain horizontal velocity with a moderate expenditure of force.

A kite is sustained and moved obliquely by the force of the wind, and the weight of the air which its fall must displace. Thus there is some analogy between a wing and a kite, it being mechanically pretty much the same thing, whether a breeze blows against a resisting surface, or a resisting surface is moved against a mass of air. Mr. Wenham cites an experiment of Captain Dansey, in which a kite, having a surface of only 55 square feet, raised a weight of 92¼ lbs. in a strong breeze, and he considers that exploring kites might be safer and more convenient than exploring balloons for purposes of war, though their employment would be dependent on the force of the wind.

Notwithstanding the ingenuity of the preceding explanations, the reader may scarcely be prepared to admit Mr. Wenham's inference, that "man is endowed with sufficient muscular power to enable him to take individual and extended flights, and that success is probably only involved in a question of suitable mechanical adaptations." An imitation of the

bird's length of wing is out of the question, as we have no means of constructing a mechanism equally strong and light, and of similar proportions in length and breadth to the weight that has to be carried. The possible solution of the problem is thus explained. "Having remarked how thin a stratum of air is displaced beneath the wings of a bird in rapid flight, it follows, that in order to obtain the necessary *length* of plane for supporting heavy weights, the surfaces may be superposed, or placed in parallel rows, with an interval between them. A dozen pelicans may fly one above another without mutual impediment, as if framed together; and it is thus shown how two hundred weights may be supported in a transverse distance of only ten feet."

Can any mechanism, either moved by man, or by inorganic motive power, be constructed to operate successfully on the principles thus explained? After carefully reading Mr. Wenham's paper, few scientific men would venture to pronounce the solution of the problem *impossible*, and we have reason to believe it has materially modified the opinions previously entertained by some of our best mechanicians and physicists. The paper is full of close reasoning, and differs entirely from the illogical speculations often put forth by enthusiastic projectors, who set to work according to methods that inevitably lead to failure.

From certain experiments described by Mr. Wenham, the nature of the difficulties to be overcome, and the kind of possibility that may be convertible into actuality, are made clearer than they were before, and many facts discovered of late years in reference to the action of screws as substitutes for paddles in steam navigation, and in relation to the flight of various shaped projectiles, may come in aid of the aëronautist.

It is remarkable that previous to the invention of balloons, flying machines were pet schemes with many philosophers. The gas balloon especially threw them into the shade, but the investigations of the infant Aëronautical Society operate in the reverse direction, and tend to create a belief that if aërial navigation is ever to assume practical importance, it must be through the agency of some mechanism more manageable and less liable to derangement than an enormous bag filled with a material that has the greatest possible aptitude for escaping through the minutest pores.

THE LUNAR APENNINES.—CLUSTERS AND NEBULÆ.—OCCULTATION.

BY THE REV. T. W. WEBB, A.M., F.R.A.S.

We come now to a portion of the lunar surface remarkable for the unusual combination of great altitude, and comparative freedom from that eruptive disturbance which has left its traces so abundantly in other elevated regions. Thus far, it has some similarity with the great mountain-chains of the earth, which it also resembles in its rapid slope in one direction, contrasted with the gradual declivity of the other side. The comparison, however, as Schmidt was the first to point out, fails in one important point here (and such indeed seems to be the case in all the lunar highland districts)—the absence of long valleys, such as either have been cut down by streams of water, or at least are now their recipients: and there is something in the structure of the N.W. edge different from the ordinary terrestrial central crest with its double slope: the massive pedestals of the loftiest peaks arise from it, but the peculiarity of their connection and their local division would, in Schmidt's opinion, scarcely find anything analogous on the earth. This district received from Hevel the designation of the *Apennines*, in accordance with his fancied analogy between the lunar and terrestial surface, and on our index-map is numbered 23. Schr. has ascribed to it a length of nearly 460 miles, with a breadth of 70 to more than 90 miles: B. and M. estimate its area at nearly 74,000 square miles: and though surpassed in height by several ranges upon the limb, it forms the most considerable mountain-mass, in the clearly-distinguishable part of the visible hemisphere. On the E. it connects itself with the conspicuous crater *Eratosthenes* (29), by a narrow prolongation of moderate height: southward it gradually declines in a great number of low ridges into the *Sinus Æstuum* (H), the *Mare Vaporum* (F), and the region about *Manilius* (24): on the W. it borders on the already-described chain of *Hœmus*, extending N.E. from *Menelaus* (15), and the *Mare Serenitatis* (E): on the N. and N.E. it culminates in a long, lofty, steep crest, somewhat curved in its general direction, and much indented in detail; this towers over the Mare Imbrium (I), with many insulated hills and long low ridges attending its base, in places rising towards it in steps, and looking, as Schmidt observes, like great masses of debris detached from the main chain during its elevation; perhaps it may be equally open to us to suppose that they may in part be the result of landslips from its edge at a more recent date. The earliest observers were astonished at

its evident height and precipitousness, and Galileo and Hevel naturally thought it the loftiest of the lunar mountains. Its shadow occasionally, about the time of the First Quarter, cuts out a broad and deep notch of the *Mare Imbrium* reaching to the terminator, and extends for a length of about 83 miles; or, which comes to the same thing, a spectator at that distance would see across the wide-extended plain its crest rising high enough into the sky to cover the disc of the rising sun; as on the other hand, at sunset its summit withdraws into darkness when equally removed from the terminator. About the First Quarter, the broad illuminated line of the main ridge runs out so far into the lunar night, that it may even be distinguished by a sharp eye without the telescope; and though a similar irregularity is obvious when the terminator passes near *Theophilus* (85), yet, according to B. and M., it was the projection of the *Apennines* which led Plutarch, and others of the ancients to infer the rugged character of the lunar globe. Hevel first measured, of course with a very rude kind of micrometer, the distance of the extreme illuminated point from the terminator at the lunar sunset, and found it $\frac{1}{17}$ of the moon's radius,* giving a very fair approximation of 16,800 ft. From its steepness, it is scarcely free from shadow through four days, and the great crest bears traces of it even as late as 24h. before full. During the lunar afternoon and evening, the shadow on the abrupt N.E. descent is replaced by light, and a little before Last Quarter I have seen it, though falling very obliquely to the axis of the chain, reflected from the precipices in a very beautiful and striking manner. The whole mass is comparatively light in colour, unbroken by darkness, excepting where penetrated by deep valleys on the S.; and there being no luminous streaks here, and the *M. Imbrium* being of a deep grey, the *Apennines* can be readily distinguished under the highest illumination. A narrow strip along its loftiest edge reaches 7°—8° of brightness; a suggestive fact, in conjunction with many other instances of the like nature, especially in the rings of craters, and one which would come into consideration in selenological inquiries; though its uncertainty and irregularity occasion difficulty in its interpretation. It would seem as though there must be a difference somewhere, either of material or of structure, in the original formation; or of internal arrangement or reflective power, superinduced at a later period in the process of cooling or consolidation, or from the presence, or relative absence, of some external influence. Among these, singly or in combination, would lie

* Galileo had previously *estimated* the projection of some elevations in various phases at more than $\frac{1}{30}$ of the diameter ($\frac{1}{15}$ of radius). Too large, but not amiss for him.

our choice of an explanation plastic enough to be moulded to the varying and capricious nature of the phenomenon; but there is an *embarras de richesses:* the number of alternatives causes difficulty in selection; and after all, it is not wonderful that we should be perplexed by an appearance which we are obliged to study at a distance, which the highest available magnifying powers can only reduce to 200 or 300 miles. What would be the difficulties and the perplexity of the geologist if he were obliged to study the structure of the earth from a corresponding remoteness, and in equal ignorance of its materials, the processes to which they have been subjected, and—save only in very rude outline—the causes and mode of their present conformation! However, this subject of varying reflective power or *local colour* deserves, and we may hope will some day receive, a greater amount of separate investigation than has yet been accorded to it.

"Almost numberless," say B. and M., "is the multitude of mountain ridges, separate peaks, and hills which cover the highland; and even with the strongest telescopic aid and the most invincible application, a delineation, entering as much into detail as is practicable, for instance, in the great *maria*, would here be unsuccessful." They say that their map contains on the W. of the crater *Conon*, that is to say, in about $\frac{1}{3}$ of the whole length of the chain, towards 500 summits, but that 2000 or 3000 would not have been enough to exhibit all which can by degrees be made out here under favourable circumstances. "A three times larger scale, a gigantic telescope, and the special examination of years, would be requisite to produce a representation approaching in accuracy to one of our better terrestrial maps."

This complexity of structure had been noticed by Schr., whose 27f. reflector, with a power of 200, had shown him in 1795-6 the innumerable minor elevations of which the great masses are compacted together, in, so to speak, tangible distinctness, though in part as minute as the smallest pins' heads; the labyrinth, in fact, is not difficult to be perceived; and I have seen something of it with a $3\frac{7}{10}$ inch object-glass.

Beginning on the S.W. from the end of *Mt. Hœmus*, which forms the S.E. border of the *M. Serenitatis*, we come first to the gradual ascent of a wide-spread plateau, 180 miles from N. to S., and 165 in the opposite direction; an extent of which we may get an idea by comparing it with the distance from London to York, between 170 and 180 miles direct. The general elevation of this mass may be perhaps 6000f., much greater than the subsequent rise of the summits, which it bears. The arrangement of most of these shows one of the peculiar parallelisms of the moon, from N.E. to S.W.: one

point among them reaches 8000f. The N. part of the *Apennines* is by far less connected with loftier and more insulated peaks: we find here a crater, *Aratus*, of great depth (Schr. thinks 3500f. or more) for its diameter of 7 miles; its 8° of brightness make it conspicuous even in the full moon; a summit close to it on the N. rises 10,400f. above the highland 30 miles to the W.; and another further to the N.W., visible from the plain towards the sunrise, mounts above that level to 14,300f. A short distance N. of *Aratus*, a high bright ridge in a meridian direction forms for some length the shore of the *M. Imbrium*. It was named *Hadley* by Schr., who gave it 13,400f. above the plain beneath; B. and M., 15,200f. —this latter about the same as our Monte Rosa, but with a far finer uprising from the neighbouring level. A summit further S.E. was measured by Schr. at 12,600f. The extreme N. termination of the *Apennines* (*Hadley* β, B. and M.) lies somewhat further out;—an insulated headland of 8500f., commanding a grand prospect over boundless plains through a great part of the horizon, broken in the N. by the extreme peaks of the *Caucasus*, and further E. by the great wall of *Aristillus*, and contrasted with the huge masses of *Hadley* on the opposite side. Rounding this promontory, and keeping along the edge of the *M. Seren.*, we come to another considerable mountain (*Hadley* Γ) worthy of notice, as the nearest vantage-ground commanding a view of the mysterious *Linné*, of which so much has lately been said, and overlooking perhaps at the present moment, though from a considerable distance, some of those wonderful processes by which the God of nature modifies the results of his own creation.

This N. section of the Apennines contains more craters than the other parts; they are all small, bright, and very regular and sharp. One lying between *Hadley* Γ and *Aratus*, and marked 84 by Lohrm., is so conspicuous, that its omission by Schr. might lead to the idea of recent formation, had not the experience of the last few years fully proved the insecure nature of all such inferences. They are, however, of use so far as they tend to a closer examination of suspected districts.

S.E. from *Aratus* lies a larger crater, *Conon*, the principal explosion-centre of the region; 10 miles in diameter, and, according to Schr., nearly 3500f. deep; B. and M. think more. A central elevation was seen by all these observers, as well as by myself with an inferior telescope; it was, however, missed by Lohrm., who, on the contrary, stands alone in mentioning a pass through the S. part of the ring, containing, a little way out, a minute crater. B. and M. differ also from him in asserting the ready visibility of the crater in the full moon—trifles of detail, which may *possibly* be some day found more

significant than they now appear. Chains of hills branch off from the neighbourhood with the usual S.W. parallelism nearly to *Manilius*, and the profusion of slightly curving ridges to the S. is said to produce a beautiful effect.

Immediately N. of *Conon* we find another of the great summits of the principal chain, *Bradley* A, which towers over the *M. Imbrium* to a height, according to Schr., of 16,250f., overtopping by several hundred feet, and greatly surpassing in relative height, the monarch of our Alps. It sends down a bright spur into the plain; and some long low ridges at its foot have a direction not parallel to the grand chain, but nearly at right angles to it, and pointing to the magnificent ring-plain *Archimedes* (33). Further S.E. is the rival summit *Bradley*, which, however, falls short of its neighbour by nearly 300f.; B. and M. give it but 14,400f. These masses stand in superb relief near the terminator.

The next eminence towards the S.E., after crossing a depression, is *Huygens*, the supreme culminating point of the whole chain; unless, as Schmidt remarks, there may be still loftier summits in positions further from the escarpment, where they would cast no measurable shadow. It is a ridge about 46 miles in length, commencing on the N. with a steep promontory, bearing a peak of 14,600f. (15,400 Schmidt), and rising gradually to a height, according to B. and M., of 18,000f. There is a difficulty in the measurement, owing to the interfering shadow of another promontory on its E. side (*Huygens* A, 12,250f.), and thus they explain the difference between their value and the 20,900f., the mean of four good measures by Schr., who also found 21,600f. by Hevel's method. Even at the lowest estimate, this is a colossal height, which, especially as taken in connection with the vicinity of the plain beneath, greatly overtops all the magnificence of Switzerland. On the very loftiest point is a minute deep white crater, detected by Lohrm.; but not a difficult object, as I have seen it with $3\frac{1}{10}$ in., and a power of 144. Such an arrangement is exceptional on the moon, and, as Schmidt observes, occurring on the summit of a long ridge, bears no analogy to the terrestrial crater at the apex of a cone.

"The magnificent clearness," say B. and M., "with which this whole steep edge presents itself at the time of the First Quarter in a bright telescope exceeds all description. Islands of light innumerable, each still more minute than the preceding, rise up out of the black lunar night, and the scene changes itself under the observer's eye, as new points are constantly becoming visible, while others are increasing and uniting themselves with their neighbours into long shining ridges."

At some distance S. of *Huygens* lies *Marco Polo*, an oval depression in the high ground, without a ring, visible chiefly in the wane, and remarkable as the centre of convergence of a number of narrow valleys. N. and N.W. of it the hill-grouping is beautiful.

The eastern part of the *Apennines* is much of the same character: a plateau covered with slightly connected ridges and chains of hills, running chiefly parallel in a S. direction. Its edge towards the *M. Imbrium* still nowhere descends below 6400 feet; a lower chain runs parallel to it through the plain at eighteen miles distance. Towards its S.E. extremity rises an almost separate mass, bearing numerous peaks, some of which attain 11,500 feet, and at this place it turns back at right angles to its previous direction, to form the N.W. shore of the *Sinus Æstuum* (H). Beyond the angle, however, and beyond some narrow gorges uniting the two plains, the original range reappears in a small, nearly rectangular plateau, whose summit, *Wolf*, attains, according to Schr., 11,700 feet (B. and M., 11,000 feet). Then a narrow and interrupted chain of inferior eminences stretches on in advance like a row of gigantic stepping-stones, till it forms a singular connection with the wall of the great crater *Eratosthenes* (29), and so brings to an end one of the most magnificent as well as extensive mountain masses of our satellite.*

CLUSTERS AND NEBULÆ.

The time of year has now become unfavourable for the examination of the fainter objects in the heavens, and those which we are going to mention ought to have been pointed out earlier. However, they may still be found in clear and moonless nights, and the knowledge of their position will prepare us for another examination under more advantageous circumstances. The first is in a space so barren to the eye that, unless we possess the convenience of divided circles (when we should find it in R.A. xiiih. 36m. D.N. 29° 1′), we must pick it up by sweeping. It lies about one-third of the distance from *Arcturus* to *Cor Caroli*, and not much out of the line; and if this part of the sky is carefully traversed, our finder will soon come across a misty speck, which in the telescope will fully reward our pains. It is

41. *The great cluster in Canes Venatici.*—Gen. Cat. 3636.—M. 3. Smyth describes this as a brilliant and beautiful congregation of not less than 1000 small stars, 5′ or 6′ in diameter, blazing splendidly towards the centre, and compressed on the *sf* side, as having no outliers there;

* B. and M. observe a considerable and unusual difference between their map and Lohrmann's "Section" throughout this intricate region.

somewhat resembling the luminous *Medusa pellucens.* H. calls it a most superb object; the stars, which he rates at 11—15 mag., form radiating lines and pointed projections from the mass, with many stragglers; and such was the power of his 18½-inch mirror with front view, as to resolve it entirely, "when not a star near it, even *Arcturus,* was visible to the naked eye for clouds." With a $3\frac{7}{10}$-inch achromatic aperture I found it, though a beautiful object, hardly resolvable; but its recent aspect with a 9½-inch silvered speculum was different indeed. There the resolution is carried very far, so that, not having looked at the preceding descriptions, I did not notice the blaze, and thought the increase of central density not greater than would be produced by an equidistant arrangement in a sphere, enclosed, however, as it would seem, by a more sparse and irregular stratum on every side. But what struck me most, in an independent observation, was the contrasted magnitudes of the stars; two sizes at least were very evident, perhaps 10½ and 12 or 13m. of Sm.'s scale. And it was not less certain that the arrangement of the larger stars had no reference to central condensation; they were sprinkled alike through (or in front of) the mass and among the extreme outliers. Their very aspect, as well as the concurring testimony of H., would prove that the difference of magnitude was a fact, and not, as he has stated in a case to be mentioned hereafter, an illusion depending upon the concurrence of several minute stars in the same visual line. The possessors of powerful instruments may be interested in knowing that 2 or 3 m. (of R. A.) *p* is a small star, which Sm. and H. found with the great reflector to be "a fine first-class double star."

We must adopt a similar process of sweeping (if we cannot point to R. A. xiih. 45m. D. N. 41° 50′) about 2¾° *n* a little *p,* from *Cor Caroli,* to find

42. Gen. Cat. 3258.—M. 94. Sm. describes it as large and bright, brighter towards the middle, with evident symptoms of being a compressed cluster. H. calls it "a very interesting object, being a nebula very suddenly much brighter in the middle on a great scale," the nucleus being 10″ or 15″ in diam. with a light equal to a 9 mag. star. It had glimpses of stars, and was not resolved but resolvable. With my $3\frac{7}{10}$-inch aperture it was like a beautiful comet; a power of 212, on 9½ inches of silvered glass, led me to think it resolvable.

Our next will be found thus: run a line from *Arcturus* through *η Böotis,* the 4 mag. star nearly W. of it, bend it gently upwards, and carry it rather more than twice as far again; it will fall upon another 4 mag. star, *ν Comæ Berenicis*; about 1° *f* a little *n* of this we shall get in the finder a misty spot, which is

43. Gen. Cat. 3453.—M. 53. "A highly compressed ball of stars," Sm. 11—15 m.; blazing in centre. H. calls it a most beautiful cluster, "with curved appendages, like the short claws of a crab, running out from the main body;" 5′ in diam., a few stars 12 mag., the rest of the smallest size, and innumerable. But to see it thus requires considerable advantages. With $3\frac{7}{10}$ inches I found it neither very large nor bright, and not very resolvable; the $9\frac{1}{4}$-inch mirror, however, masters it, showing not much central compression and many outliers, among which, as in the case of M. 3, are many of the brighter stars, there being evidently several magnitudes. A low power shows a pretty open pair *s*. Sm.'s remark upon this cluster may well be transcribed here: "the contemplation of so beautiful an object cannot but set imagination to work, though the mind may soon be lost in astonishment at the stellar dispositions of the great Creator and Maintainer. Thus, in reasoning by analogy, these compressed globes of stars confound conjecture as to the modes in which the mutual attractions are prevented from causing the universal destruction of their system."

While on the subject of nebulæ, we may mention that a suspicion may perhaps be entertained of some variation in the dark rifts or "canals" discovered by Bond in the Great Nebula of *Andromeda* (Int. Obs. IV., 346). When trying an 8-inch silver-on-glass speculum by Mr. With, 1864, Aug. 31, I have noted "both canals traceable, though very feebly, for a long distance." During the past winter I have been unable to make them out to any certainty with my $9\frac{1}{4}$-inch mirror, which, though its figure is not yet quite complete, is competent to show a black division in γ^2 *Andromedæ*; and I find that the experience has been similar of Mr. Matthews with $10\frac{1}{4}$-inches, and of Mr. With in the use of a $12\frac{1}{4}$-inch mirror of very fine quality. This point certainly deserves attention. It has been suggested by the latter observer, that a rotation of the whole mass would be capable of producing such a result. Were its structure clearly gaseous, change would be less surprising; but Huggins finds a continuous spectrum. It is true, however, that its red end is wanting, and that it is evidently crossed either by bright or dark lines; and these peculiarities, which are common to it, more or less, with 1949 (M. 81), 1950 (M. 82),* and the well-known and brilliant M. 13 (in *Hercules*), have naturally led to a suspicion on the part of that eminent observer, noticed in a previous number, that the apparent stars of some clusters may not be of what we commonly understand as a stellar character—that is, analogous to our

* Int. Obs. VI., 348.

sun, or Sirius, or Wega. Setting aside for the present the inevitable inference from spectrum-analysis, it certainly seems very difficult to ascribe a starry nature to such luminous masses as the *Andromeda* nebula, or its analogue M. 81. It is easy to find cases of resolution, separately, of either a very feeble mist, or a very brilliant and blazing nucleus. But it is not easy to conceive the combination of these two in one object, as in those instances. The stars whose light compose that faint haze, so diffuse that it has no assignable termination, but dies imperceptibly into the dark sky, and can perhaps only be traced in its full extent by a rapid movement of the telescope, must be individually so excessively minute, that such an accumulation of them as would form a bright and vivid nucleus is quite beyond the bounds of probability. No justifiable stretch of imagination could compound the central blaze of those nebulæ out of materials individually less perceptible than the 20th mag. of H., or the 13th of O.Σ. We might indeed have recourse to the supposition that the components all progressively increase in magnitude or luminosity towards the centre; but this, not to mention that it finds little countenance in the known arrangement of stars of various sizes in globular clusters, of which two instances have been given in the present article, is liable to the grave objection of being a special and gratuitous assumption in order to escape from a difficulty. On the other hand, the bare inspection of these nebulæ conveys the strong impression of an uniform material, capable either of great extremes of condensation and rarefaction, or of very varying degrees of luminosity dependent upon unequal temperature, and therefore, in all probability, neither solid nor fluid, unless it might be in a state of extreme division. In short, we can conceive these objects to be an incandescence of either gas, or mist—that is, exceedingly comminuted fluid; or dust—that is, similarly attenuated solid matter; but we can scarcely reconcile their aspect with a stellar composition. Had the spectroscope told us unequivocally that we were wrong, we must have given way to its decision; but we see that its verdict is so far ambiguous as not altogether to shut up the inquiry.

OCCULTATION.

June 15th, B.A.C. 5579, 5 mag. 7h. 7m. to 7h. 41m.

MOON COLOURS.

THE observations on the lunar crater Linné, have established beyond a doubt, firstly, that changes, of an apparently volcanic nature, still occur on the surface of our satellite, and secondly, that alterations take place at a rate sufficiently rapid to hold out the hope that even a brief period of accurate study and comparison may suffice to ascertain and demonstrate their occurrence. It may be that the enormous craters which form such conspicuous features in lunar scenery, belong to a past epoch, when the crust of the moon was in a plastic state, and fresh operations on so grand a scale may not be likely to occur. There would, however, remain the probability of our witnessing alterations which, if less gigantic, might be equally instructive, and for their ascertainment two things are requisite, an exact knowledge of forms and a similar knowledge of colours as they exist at any given time, and as they are modified by local action. The great map of Beer and Mädler, the maps of Lohrmann, etc., have done much for lunar forms, and the British Association map, on which Mr. Birt is engaged, will be of the highest value to future observers, although we must observe that the Moon Committee cannot arrive at a satisfactory result if they leave Mr. Birt to work with a telescope ridiculously small, and which cannot possibly show one quarter, perhaps not one-twentieth, of the minute objects he is expected to lay down with mathematical accuracy. An instrument—say a silvered glass reflector—of at least ten or twelve inches, must be regarded as indispensable, and we hope we may soon hear that he will be provided with a telescope equal to the majority of those which are employed in public and private observatories.

All astronomers perceive the importance of noticing and recording changes of form, but changes in colour may prove nearly as important, and no means of estimating them have yet come into general use. Admiral Smyth's *Sidereal Chromatics* suggested at the time of its publication the propriety of establishing similar standards for the moon, for it is clearly not sufficient to study variations in luminosity without also taking cognizance of modifications of tint or hue.

Few observers can have watched the lunar seas and plains for any length of time without finding evidence that colour changes do occur. The green tint noticed on some spots seems especially to vary, and is often invisible, while modifications appear in the neutral tint blues or ochrey browns. Although we see the moon as an opaque object, its tones of colour are extremely difficult to imitate by opaque pigments.

They are, on fine nights, more like the effect of white light seen through delicate transparent screens of different hues, and could probably be better imitated by transparencies than by drawings on paper, like the star colours of Admiral Smyth, which ought by the way to be imitated in transparent glass.

Mr. Birt has shown us a series of tints on paper which could only be imitated by careful hand-colouring at considerable expense, and he also allowed us to examine an instrument which he terms a "homo-chromoscope," which he brought before the Astronomical Society in 1861, and which is well worth serious consideration. It consists of a number of tints in circular patches painted on a glass slide, and moving in a frame, so that any one can be brought to a central aperture, through which it is illuminated from behind, and observed in front. The light is intended to be reflected by a sheet of white paper suitably placed to catch the rays from a small lamp, and the observer would look with one eye through his telescope, and with the other at the "homo-chromoscope" until he found a tint corresponding with that under his notice upon the moon's surface. The instrument thus devised by Mr. Birt is only in an experimental stage of its existence, but we are anxious to call attention to it, as it could only be brought to a satisfactory state by the co-operation of other observers, and by securing for it, when completed, a sufficient sale.

The first thing to do would be to get a moderate number of good observers, whose eyes are tolerably free from any form of colour-blindness, to agree upon the principal tints. From experiments we have made with a fine refractor of 3 inches, and with a 6½ inch silvered mirror, we find that ordinary observers differ in the amount of yellow they see in the moon, in the quantity of purple they notice, and in their estimation of the greenish tint, which is often invisible to ordinary eyes, and which probably does not always exist. Dull, but *clear* ochrey-yellows, neutral tint blues, sometimes passing into browns, at others into purples and purple greys, all more or less differing from terrestrial colours, and therefore difficult to describe in terms usually applied to them, are what, perhaps, would be generally agreed to exist; but it would be worth while for a "Moon Committee" to request a couple of good colour artists to paint on glass, in transparent tints as near as possible, the tints of Mare Serenitatis and Tranquilitatis, and send copies to ten or twenty observers, and ask for their reports. Many persons find themselves much assisted in estimating star colours or brown tints, by being told how others see them, and this must not be regarded as exciting a prejudice in favour of the tint thus selected, but rather as indicating what delicate peculiarity is to be looked for. If a few

of the most conspicuous lunar tints could be settled by the agreement of a moderate number of good observers, a foundation would be laid for further work.

If the plan of transparent disks should be preferred to that of tints painted on paper, viewed by reflected light, a small lamp should be agreed upon as the source of light. Perhaps the benzoline lamps recently introduced from France would answer, or camphine, or the fluid called photogene might do. Paraffine, as usually burnt, is too yellow, but selecting a fluid, and a mode of burning it which gives an approximately white light, and furnishing the lamp with a bluish tinted glass, would ensure the absence of any disturbing colour; and if appropriate lamps were made cheap, and sold in conformity with a recognized standard, they would be generally used in observatories, and help to secure a uniformity of result.

Our object now is merely to start an idea. If lunar observers think proper to support it, the method of carrying it out will soon be found. Perhaps, instead of reflecting the light of a lamp from white paper, the best way would be to transmit it through the disks of ground glass, recommended by Mr. Slack to microscopists in our last number; but these, if used, must be made all alike.

PROBABLE CONNECTION OF COMETS WITH SHOOTING STARS.

BY W. T. LYNN, B.A., F.R.A.S.,
Of the Royal Observatory, Greenwich.

Professor Adams, at a recent meeting of the Royal Astronomical Society, completely established as a fact, what had been previously suspected by an Italian astronomer, named Schiaparelli, of Milan, that the shower of meteors, which is occasionally and at certain intervals witnessed in the month of November, moves round the sun in an orbit almost identical with that of a comet observed early last year (Comet I., 1866),* which performs a revolution in little more than 33 years. It has also been shown to be highly probable that the August meteors may be identified with a comet seen in 1862, and the April meteors with a comet discovered at New York in the spring of 1861. The conjecture naturally suggests itself that the comets in question compose in fact a kind of congeries, or assemblage of meteors, moving within small distances of each other, which, at a considerable distance, present the appearance of single bodies.

* Discovered by Tempel at Marseilles in 1865, December 19. It was a very faint telescopic comet, and destitute of tail.

From the feeble attraction which was known to hold together the different parts of comets, it appeared not unlikely that they might suffer partial dispersion, and leave behind them a larger or smaller number of particles, which would cause, in the case of periodical, or regularly returning comets, the formation of a ring, more or less complete, along the orbit of the comet. If the comet passes through the plane of the earth's orbit at about the same distance from the sun as the earth itself is, the earth, when it comes to that part of its orbit, must pass through the ring of meteors, causing a display of shooting stars; so that if the ring were quite complete, the earth would pass through it every revolution round the sun, and we should see a meteoric display every year at the same day of the year. But if the ring be only partial, we shall only see a shower of meteors at intervals of several years. The ring therefore produced by the comet of 1862, causing the August meteors, would seem to be more complete than that produced by the comet of 1866, causing the November meteors. Indeed, the latter ring would seem to consist chiefly of but one branch, so to speak, of some length; so that we see a grand display only once in each revolution of the comet or meteors, when the latter are passing through one of the nodes of their orbit; but this occurs sometimes for two or rarely three years in succession.

Now, a very curious idea struck Professor Bruhns, of Leipsic, on considering these recent discoveries. Biela's comet was observed in the year 1846, as we stated in detail in the April number of the INTELLECTUAL OBSERVER, to have separated into two fragments. Could this have been a consequence of its encountering part of one of these meteoric rings, whilst the cohesion of its own separate particles of matter of the same kind was too weak to prevent their being diverted into parts with new centres of attraction by even the slight impulse occasioned by their intermingling with the meteors? The result of his calculation showed that this was really by no means improbable. At the time of the comet's separation, about the end of 1845, he was able to prove that it was, if not actually in, at least very near the orbit of the November meteors.

This remark was followed by an equally interesting one made by Professor d'Arrest, of Copenhagen. Quetelet, director of the Observatory of Brussels, and after him the celebrated Humboldt, had already called attention to a fall of aërolites, which frequently occurred early in the month of December. Now, d'Arrest noticed that this was at the very time that the earth passed through the orbit of Biela's comet.* Hence it appeared probable that that comet had also left particles behind

* *Astronomische Nachrichten*, No. 1633.

it some time anterior to its well-known division in 1845–6; and if this afterwards took place to a still greater extent from the feebleness of coherence of that comet, its almost complete dispersion, and therefore its ceasing to be visible after 1852, would be accounted for.

D'Arrest particularizes the following dates of the December showers:—

1741, Dec. 5.

1798, Dec. 6.—Brandes gives the number of shooting stars observed at Bremen at 2,000.

1830, Dec. 7.—Raillard reports an "extraordinary apparition of shooting stars."—*Comptes Rendus*, vii., p. 177.

1838, Dec. 6.—Flaugergues, at Toulon, saw many meteors "from a point situated at the zenith at nine o'clock in the evening."

1838, Dec. 7.—Edward Herrick, at New-Haven (America), "from a point of the sky situated near the chair of Cassiopeia."

In other years, Colla, Heis, and Quetelet observed many shooting stars on the same nights. According to Flaugergues the radiant-point lies in about R.A. 30°, declination 43° north. Herrick would give a somewhat less right ascension and greater declination; Heis a less right ascension, and less declination; but, at any rate, the December phenomenon differs from those of August and November in this respect, that the meteors appear, at a place in the parallel of central Europe, to proceed from near the zenith.

The corresponding longitude of the earth is about 75°, nearly enough coinciding with the descending node of Biela's comet, the longitude of which, between 1772 and 1832, decreased from 73° to 68°; and it is well known that at this nodal passage the radius vector of the comet is about equal to the mean distance of the earth from the sun.

D'Arrest then calculated the place from which particles moving in the orbit of Biela's comet must appear to radiate at the rencontre with the earth at the nodal passage, and found it to be about R.A. 25°, declination 51° north; so that, to an observer in the parallel of Toulon or New-Haven, they would appear to come from a point in the neighbourhood of the zenith about nine o'clock in the evening of Dec. 5—6. It is therefore possible that they may become visible in the form of the December shooting stars, though d'Arrest says that in his mind the difficulties connected with the assumption are very great.

"Can it be," he asks, "that the celebrated shower of meteors observed by F. Berthou, in Brazil, on the 11th of December, 1836, belongs to those here noticed?" An extraordi-

nary quantity of stones then penetrated into the ground to the depth of several feet, and were scattered over a radius of more than ten leagues.*

Do the great showers of 1798 and 1838 point to a larger display at the end of six periods of 2435 days each, and may another large appearance be expected in 1878?

We will conclude by translating the last paragraph of d'Arrest's interesting paper:—

"Finally, it may be asked whether the intense northern lights, frequently observed coincidently with meteoric showers, may have been the united glimmer of more distant portions of particles dispersed through the orbit of a comet? That some connection exists between meteoric showers and northern lights has been incontestably proved by Quetelet many years ago. If showers of shooting stars and rings of meteors really have any connection with cometary phenomena, the hope is afforded that some explanation may be arrived at concerning the nature of the aurora borealis, and also concerning magnetic storms."

The whole subject of the connection between meteors and comets is exceedingly interesting, and is accordingly engrossing a large share of the attention of astronomers. We seem to be, as it were, on the eve of great discoveries.

ARCHÆOLOGIA.

The Rev. Canon Greenwell has been again pursuing his interesting researches among the tumuli of the Yorkshire wolds. The tumuli which have been the scene of Mr. Greenwell's recent labours are situated on the estates of Mr. B. Foord Bowes, on the mid-wold range, at Weaverthorpe, Cowlam, and Burrow, near Driffield. The one first opened was, in its present condition, a low mound of earth, fifty-six feet in diameter, and two in height. It contained a male skeleton, deposited in the centre, in a circular grave, sunk five feet six inches into the rock, and ten feet in diameter. The body had been laid on its left side, with the head to the north-east, the hands placed in front of the breast, and the knees drawn up to the elbows. With it was found the blade of a bronze dagger, which had had a wooden handle fixed to it by the three bronze rivets, the latter still remaining in their places. There was also a large flint knife, and an implement which is described in the printed account as "a bronze awl or bodkin." Beneath the chin lay five very large polished jet buttons, full an inch and a half in diameter, and one button of baked clay, of similar size and form, but ornamented with four lines radiating from the centre. One of the buttons had

* *Comptes Rendus*, viii., p. 87.

three holes on the back, the others two each. A fine bronze axe was found behind the skeleton; it appeared to have been set in wood. All the bronze articles bore a very fine patina. A deposit of animal bones was found on one side of the tumulus.

The other tumuli, opened on this occasion, formed a group of low, flat barrows, on the top of the Burrow wold, which had become almost obliterated by tillage. Two of them contained the remains of females, who had been buried with their personal ornaments. The one first opened was twenty-two feet in diameter, and two feet in height. In the centre, upon the original surface of the ground, the female skeleton was laid on its left side, with the head towards the north-east, and the hands up to the head. The body had been doubled up. On the right wrist was a beautiful bronze armlet, of the snake-head pattern, with a succession of oval swellings lengthwise. Close to it was a delicate bronze fibula, described as "of the bow shape," and of extremely elegant workmanship, which had originally had a tongue of the same metal, but it had been broken off and replaced by an iron tongue, "fixed in a piece of wood, which passed through the bronze coil of the fibula." The lady had been buried with a necklace of beads, of which fifty-three were of glass, and seventeen of amber. Amber beads, it may be remarked, are usually characteristic of the post-Roman period. The glass beads are described as extremely beautiful, all blue and ornamented, with one exception, with a zigzag pattern in white enamel. The exceptional one was larger and more globular in form than the others, and was ornamented with annulets of white. Scattered about the mound were found a quantity of potsherds, and a few flint chippings. The other tumulus was twenty-four feet in diameter, and only one foot in elevation above the surrounding ground. At the centre, as in the other, on the surface of the ground, lay the skeleton of a female, on its left side, with the head to the north, the hands raised to the face, and the body doubled up. As in the tumulus last described, the lady had borne on her right wrist a bronze armlet of the most beautiful description, "resembling a delicately-formed cog-wheel, with rounded teeth on both sides, the rim between the teeth being ornamented with three grooved lines."

An interesting discovery has been made in France of what is designated as a Celtic Foundry of the Bronze Age. It appears that a peasant, while digging in a potato-field in the village of Larnaud, near Lons-le-Saunier, in the department of the Jura, struck against a piece of metal, which he immediately drew to the surface. The spot was examined with care, no doubt in the hope of finding treasure; and at a depth of a little more than a foot, and within a space of somewhat more than a square yard, an immense number of objects in bronze, consisting on the whole of upwards of eighteen hundred pieces, was found matted together. Among them were arms, implements, personal ornaments, and other things of almost every possible description; bars of bronze, residues from melting, two moulds, saws, a file, chisels, and punches, knives, fish-hooks, harpoons, arrow-heads; fibulæ, buckles, buttons, brooches, bracelets, and great varieties of other personal ornaments; chains, apparently

belonging to horses' trappings, umbos of shields, swords and other arms, axes, sickles, hammers, etc., etc. The ignorant peasants who had found these interesting objects immediately carried them to a brazier, who valued them at one franc and forty centimes the kilogramme, and the whole amounted to about sixty-six kilogrammes (a kilogramme being rather more than two pounds three ounces English); but the discovery having come to the knowledge of a local antiquary, the whole were saved from the melting-pot, and secured for the local museum. They are described as being all of good workmanship and elegant design. Unfortunately, the published report of the discovery is not accompanied with engravings, without which we can form no very definite opinion of them. It appears to us, however, that it is a mere assumption that they belong to a bronze age, or that this was the site of a manufactory of bronze. They evidently formed the stock-in-trade of some general dealer in objects made of bronze; perhaps an itinerant merchant, who moved from locality to locality, and of course carried no other metal than that in which he dealt, but that must not be taken as evidence that other metals were not in use at the same time. The discovery of a group of objects made all of gold would not be taken as a proof that they belonged to a golden age, in which that was the only metal in use. Similar discoveries of bronze objects, with no intermixture of other metals, are not at all uncommon in our island, though in smaller quantities, and they are usually accompanied with pieces of the residuum of the melting-pot, and of pieces of metal to be used in it, and sometimes with moulds. In each case they represented, no doubt, the stock of some itinerant dealer. It was the common practice to put things of value in a place of security by burying them in the earth, and this is, no doubt, the proper explanation of deposits of this description. It may be satisfactory to some of our friends who are going to the French Exhibition to learn that, after the 27th of the present month of May, the whole of the objects found on this occasion will be on view in Paris, at the house of M. Mazaroz-Ribaillier, sculptor, Boulevard des Filles du Calvaire, No. 20.

We are glad to be able to announce that preparations are making for recommencing EXCAVATIONS AT WROXETER, the site of the Roman *Uriconium*, without delay. It is proposed to begin with a large square room, adjoining the apartment containing the remains of furnaces, which has been called the enameller's shop, and the opening of this room is expected to lead to very interesting results.

T. W.

PROGRESS OF INVENTION.

New Apparatus for Condensing Light.—An apparatus, which has been found to render the light from a given source twelve times as great as in ordinary circumstances, and which, when properly constructed, is believed to be capable of still more important results, has been lately invented at Lille. It consists of a hollow copper vessel, in the form of an ellipsoid of revolution, and having its interior surface silvered. At the extremity of the major axis, which is farthest from the focus in which the source of the light is placed, is an aperture of suitable size, that allows an exit to the rays, after one half of them have been reflected once, and the remainder three times. The extreme rays of the luminous cone thus emitted forms an angle of 45°, but should it be desired to render the rays parallel, they are to be thrown on a prismatic lens. To afford a means of ascertaining the state of the light within the instrument, apertures are formed in it which are fitted with lenses that project images of the light, or a screen arranged for the purpose, but do not sensibly affect the intensity of the light.

Engraving on Steel.—Photography has recently been applied very ingeniously to this purpose. The steel plate, having been covered with a mixture of gelatine and bichromate of potash, or bitumen of Judea, is exposed under a negative obtained in the camera; after which the soluble portions of the coating are washed off. The surface of the steel will then be found more or less uncovered in the lights of the picture. The plate is next gilt in the usual way, by means of the electrotype process; after which, the remainder of the gelatinous coating is to be removed. It is then immersed in dilute acid, which acts on the portions not protected by the gilding, that is on those which are to represent the shades of the picture; the various grades being produced by the presence of a greater or less number of particles of gold, which more or less protect the surface. When the plate is removed from the acid, and washed, a number of copies may be printed from it, and it will be found to produce very excellent pictures.

The Drummond Light.—The opacity of the cylinders of lime used with the Drummond light, is in many cases the source of considerable inconvenience. This is obviated by very simple means, which consists in the use of plates formed of magnesia and chloride of magnesium. Being transparent, they permit the light to be seen at both sides. One of them suffices for a small lamp; for a large one, such, for example, as is used in lighthouses, several are arranged around a centre.

The Glazing of Porcelain.—In ordinary cases a glazing is used for porcelain, which has the convenience of being very easily fused, but the disadvantage of being very readily attacked by acids, and being extremely liable to become full of cracks. Moreover, the presence of the lead, which is one of its constituents, is the source of

considerable danger. A glazing material free from these objections, while at the same time it is easily used, and very economical, is now employed very advantageously Its action depends on the solubility of the alkaline silicates. The article to be glazed is either brushed over with the alkaline solution, or is immersed in it—a larger quantity of it being absorbed when the latter method is adopted, on account of the porosity of the unglazed article. It is then exposed to a temperature which fuses the compounds of silex and the earths. The glazing thus produced has a fine appearance, and is of a most durable kind, being unaffected by caustic liquids or atmospheric changes.

Economic Mode of Reducing Copper.—It consists in the application of water when the ore is at a high temperature. As soon as the ore has reached a red heat, water is projected upon it in the form of a fine spray, and after the white vapours have escaped, the temperature is raised to that of fusion. With good ore this process is sufficient; with ores of an inferior kind the product of the first fusion, when it has cooled, is broken in pieces, and the process of heating to redness and applying water is repeated. And when fusion is produced, powdered charcoal and lime are added, the whole being thoroughly mixed. The scoria thus formed is removed, and the process is finished by transmission of atmospheric air through the fused mass.

Protection of Armour Plates from Corrosion.—The fact that even cast iron may be coated with glazing, by spreading on its surface a fusible glass as powder, or, which is better, the materials of which glass is made, and then raising to a proper temperature, has been applied to the coating of iron on the large scale, and it has been proposed to protect armour-plates in this way. The adhesion of the enamel thus produced on the surface of the iron is very firm, since the metal is oxydized, and the oxide combining with some of the constituents of the glass, a compound glass, which adheres strongly to the iron, is formed. If the coating is not too thick, it has but little tendency, even with considerable changes of temperature, to separate from the metallic surface; and it forms a protective coating which, even under very rough usage, and considerable alterations of temperature, has been found, when skilfully produced, to last for years uninjured.

PROCEEDINGS OF LEARNED SOCIETIES.

ROYAL SOCIETY.—*May* 16.

"On the Occlusion of Hydrogen by Meteoric Iron." By Thomas Graham, Esq., F.R.S. In a paper communicated to the Society in June last, Mr. Graham has shown that metals under certain conditions absorb and retain gases, each metal exerting a selective power. The author now considers that the investigation

of the natural gases of native metals, especially gold and iron, may throw considerable light on their formation. The iron of the well-known Lenarto fall (which, from its purity, appears to be well adapted for the experiment) gave, when distilled in vacuo by means of Sprengel's mercurial exhauster, 2·8 times its volume of gas, of which 85 per cent. was hydrogen, the remainder being nitrogen, and a small amount of carbonic oxide. Messrs. Huggins and Miller have established the presence of hydrogen in the atmosphere of those fixed stars of which Alpha Lyra is the type. It is probable, therefore, that the iron must have occluded its hydrogen from a similar source.

GEOLOGICAL SOCIETY—*May.* 8.

Warington W. Smyth, Esq., M.A., F.R.S., President, in the Chair.

The following communications were read:—

1. "On New Specimens of Eozoon." By Sir W. E. Logan, F.R.S., F.G.S.—Amongst several additional specimens of *Eozoon* which have been obtained during recent explorations of the Canadian Geological Survey, is one which was found last summer by Mr. G. H. Vennor, in the township of Tudor, county of Hastings, Canada West. It occurred on the surface of a layer, three inches in thickness, of dark-grey micaceous limestone, or calc-schist, near the middle of a great zone of similar rock. This Tudor limestone is comparatively unaltered, and in the specimen obtained from it the skeleton of the fossil, consisting of white carbonate of lime, is imbedded in the limestone without the presence of serpentine or other silicate, a fact which the author regarded as extremely favourable to the view of the organic origin of *Eozoon*. Sir William Logan also described the nature and relations of the rocks of other localities which have recently yielded *Eozoon*, especially Wentworth, Long Lake, and Côte St. Pierre.

2. "Notes on Fossils recently obtained from the Laurentian rocks of Canada, and on objections to the organic nature of *Eozoon*." By J. W. Dawson, LL.D., F.R.S., F.G.S.—The first specimen described in this paper was the one from Tudor referred to in the previous communication. Its examination had enabled Mr. Dawson to state that in it the chambers are more continuous, and wider, in proportion to the thickness of the septa, than in the specimens found elsewhere, and that the canal system is more delicate and indistinct. Without additional specimens the author could not decide whether these differences are of specific value, or depend on age, variability, or state of preservation; he therefore referred the specimen provisionally to *Eozoon Canadense*, regarding it as a young individual, broken from its attachment and imbedded in a sandy calcareous mud. Its discovery afforded him the hope that the comparatively unaltered sediments in which it had been preserved, and which have also yielded worm-burrows, will hereafter still more largely illustrate the Laurentian fauna. After giving short

descriptions of new specimens from Madoc and from Long Lake and Wentworth, Dr. Dawson discussed the objections of Prof. King and Dr. Rowney to the view of the organic nature of *Eozoon*, and stated that those gentlemen had failed to distinguish between the organic and the crystalline forms, as was especially illustrated by their regarding the veins of crysotile as identical with the tubulated cell-wall of *Eozoon*.

ROYAL MICROSCOPICAL SOCIETY.—*May* 8.

James Glaisher, Esq., F.R.S., President, in the Chair.

The Rev. J. B. Reade, F.R.S., read a paper on a remarkable dichroic liquid obtained from a pond. The water was tinged with a colouring matter which appeared red by reflected, and violet by transmitted light. The peculiarity seemed to result from the action of growing organisms upon soluble albumen, and Mr. Reade exhibited a similar fluid artificially formed. Mr. Browning explained the character of its spectrum, which was very remarkable, the principal characteristics being two cloudy absorption bands, one in the orange and another in the green.

Two new lamps were described by Ellis G. Lobb, Esq., one a small camphine lamp, patented by Young, and the other a cheap and convenient travelling lamp, devised by Mr. Piper; both were considered very handy. Dr. Lionel Beule read a very interesting paper on "Nutrition considered from a Microscopical Point of View," in which he developed the hypothesis that all matter capable of growth by nutrition originates by descent from similar matter. He also showed that the serum of the blood, and not the globules, was its nutritive portion.

NOTES AND MEMORANDA.

The Stability of Gun Cotton.—*Proc. Roy. Soc.*, No. 92, contains a paper on this subject by Mr. F. A. Abel, F.R.S., in which he states that if gun-cotton is prepared in strict accordance with Von Lenk's system, it will resist to a remarkable degree the destructive effects of prolonged exposure to temperatures even approaching 100° C. Ordinary gun-cotton contains small quantities of nitrogenous impurities, which decompose and give rise to a free acid when exposed to heat. One per cent. of sodic carbonate neutralizes this acid, and is sufficient to prevent serious change. Water acts as a most perfect protection to gun-cotton (except when it is exposed for long periods to sunlight), even under extremely severe conditions of exposure to heat. It is not necessary that the gun-cotton should be wet, a slight dampness being sufficient.

Mimetic Butterflies.—Mr. Wallace has been exhibiting at 76½, Westbourne Grove, a very interesting series of objects from the Indian archipelago. Amongst them is a case with a label affixed, stating that it contains fourteen butterflies. The visitor is completely puzzled, seeing only twigs with dead leaves upon them. On closer examination, it appears that each seeming dead leaf is a butterfly, with wings folded, and perched on the twig so as exactly to resemble the insertion of a leaf. To make the imitation more complete, the undersides of the wings, which alone are visible, are speckled with dull colours resembling patches of microscopic fungi.

SEPARATING POWER OF TELESCOPES.—Mr. Dawes has a paper in *Monthly Notices* which forms the introduction to his "Catalogue of Micrometrical Measurements of Double Stars," in which he states that a telescope with one-inch aperture will just separate two sixth magnitude stars, if their central distance is 4".56, and the atmosphere favourable. Hence the separating power of any given aperture, a, will be expressed by the position $\frac{4".56}{a}$. According to this formula a three-inch aperture should divide stars 1".52 apart; a four-inch 1".14; a five-inch, 0".91; a six-inch, 0".76; and a twelve-inch 0".380. These calculations refer to refractors; the *finest* reflectors, like Mr. With's mirrors, probably have some advantage over refractors.

ACTION OF TREES ON RAINFALL.—M. Becquerel states (*Comptes Rendus*), that in wooded localities the maximum rainfall occurs in summer, and in non-wooded localities in autumn.

TRANSPARENCY OF RED-HOT IRON.—In a communication of Father Secchi to the French Academy, it is stated that a tube of forged iron was being constructed for a meteorograph, and he was afraid that the new tube might not preserve a vacuum as accurately as one previously made. It was accordingly made cherry red, almost white hot, and viewed in a dark place, when a slight flaw was seen inside it. Father Secchi observes, "That red-hot iron is transparent to a depth of half a centimetre at least.

POISONS OF SPREADING DISEASES.—Dr. Richardson has published in pamphlet form* his lecture delivered before the Sewage Congress, in which he refers to an observation of Dr. Salisbury during the American War, that a number of men who slept on straw containing a certain mould or fungus, were seized with measles, and he found that by inoculating himself and his family with the fungus, measles was produced. Dr. Kennedy, of Dublin, is stated by Dr. Richardson to have made similar observations. Dr. Richardson considers iodine as the best chemical agent for destroying organic poisons. Iodine placed in a box covered with muslin will diffuse itself at a temperature of 70°, at the rate of a drachm in twenty-four hours. Heat and sunlight favour the destruction of the poisons.

AERIAL NAVIGATION.—At a meeting of the French Academy, 29 April, M. Babinet spoke favourably of a machine invented by M. de Louvrié. The motive power consisting of hydrocarbon vapour mixed with air, and exploded in a cylinder having one circular opening. Twenty or thirty explosions per minute were said to suffice. MM. Babinet, Piobert, and Delaunay were requested to examine the apparatus and report upon it. *Cosmos* gives some further particulars of remarks made by M. Babinet, and not printed in *Comptes Rendus*, from which it appears that the apparatus is formed of an inclined plane, making a small angle with the horizon, and moved horizontally by the reaction of a series of explosions producing currents in the opposite direction. M. Louvrié has only made the machine on a small scale, and M. Babinet wished the Academy to have a larger one constructed. M. Flammarion (in *Cosmos*), describing the plan, says that a kite, ten metres, each side formed of wire gauze, with the interstices filled with gutta percha, is to be solidly fixed to a car of thin copper, able to hold a man lying down, and to contain a supply of the combustible liquid at its extremities. The inclination of the plane of suspension is to be moved as required by wire ropes, worked by an endless screw. At each end of the apparatus, cylinders of steel are to be filled with a mixture of air and petroleum vapour, by means of a pump, and exploded alternately by electric spark. From this description we should not like to join M. Babinet in predicting the success of the scheme. It seems sure to fail.

* Churchill and Sons.